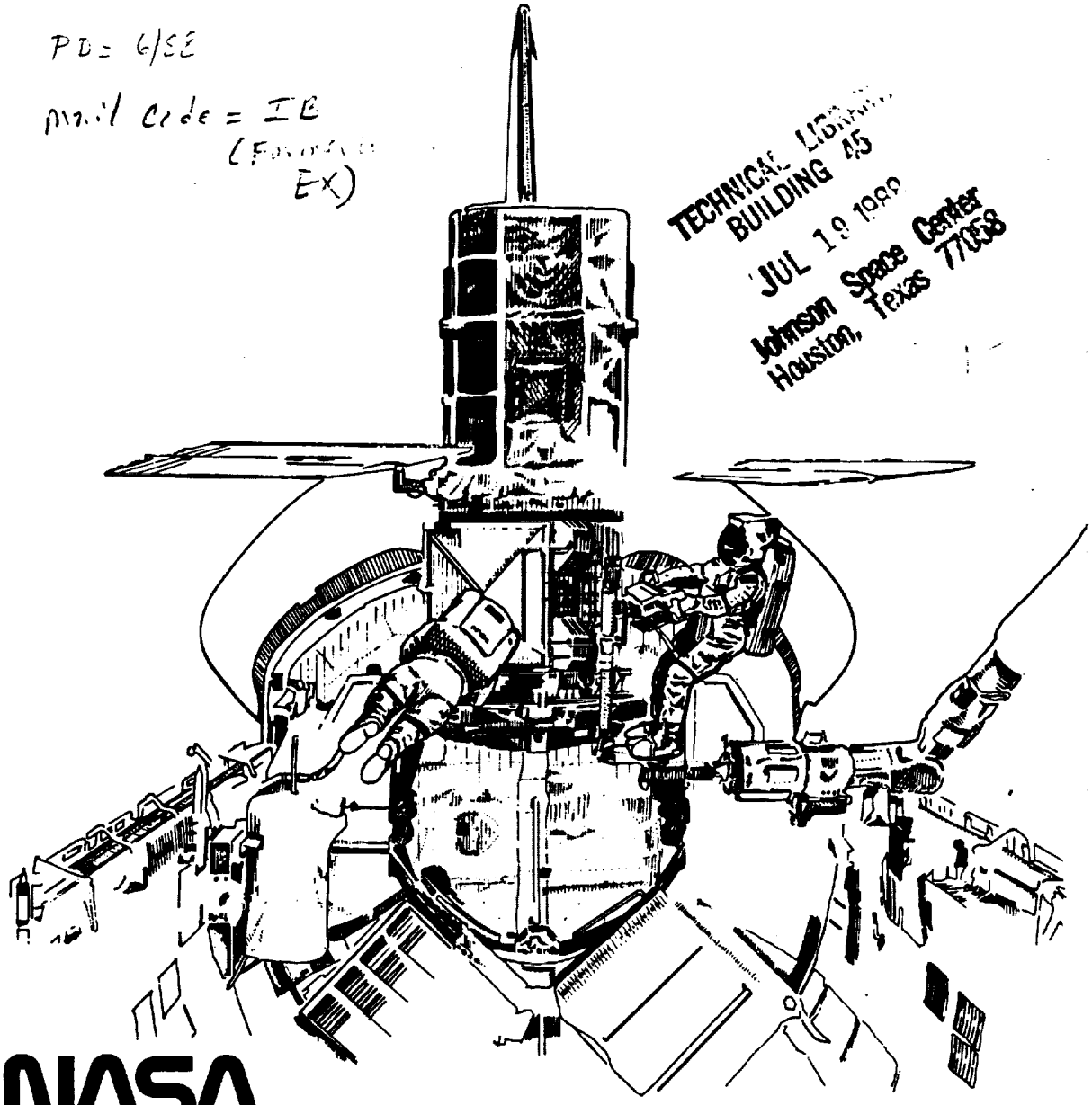
Satellite Services System
Servicing Equipment Catalog

New Initiatives Office
Advanced Projects Definition Office



NASA
National Aeronautics and
Space Administration

Lyndon B. Johnson Space Center
Houston, Texas

PREFACE

The purpose of this document is to identify existing and planned equipment items that could be used for on-orbit satellite servicing.

The Servicing Equipment Catalog was composed and complied by the JSC Satellite Services System Working Group which consisted of NASA, DOD, Industry, and International participants. Special thanks are given to the following individuals from Lockheed Engineering and Management Services Company, Inc., and Omniplan Corporation.

LEMSCO	Herbert G. Patterson Lisa B. Sloan Lana R. Arnold
Omniplan	David A. Krenek Sally L. Harrison

Information contained herein should not be construed as being official NASA Policy, nor does it represent any commitment or obligation on the part of NASA.

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3.8164

Gordon Rysavy 6-6-88

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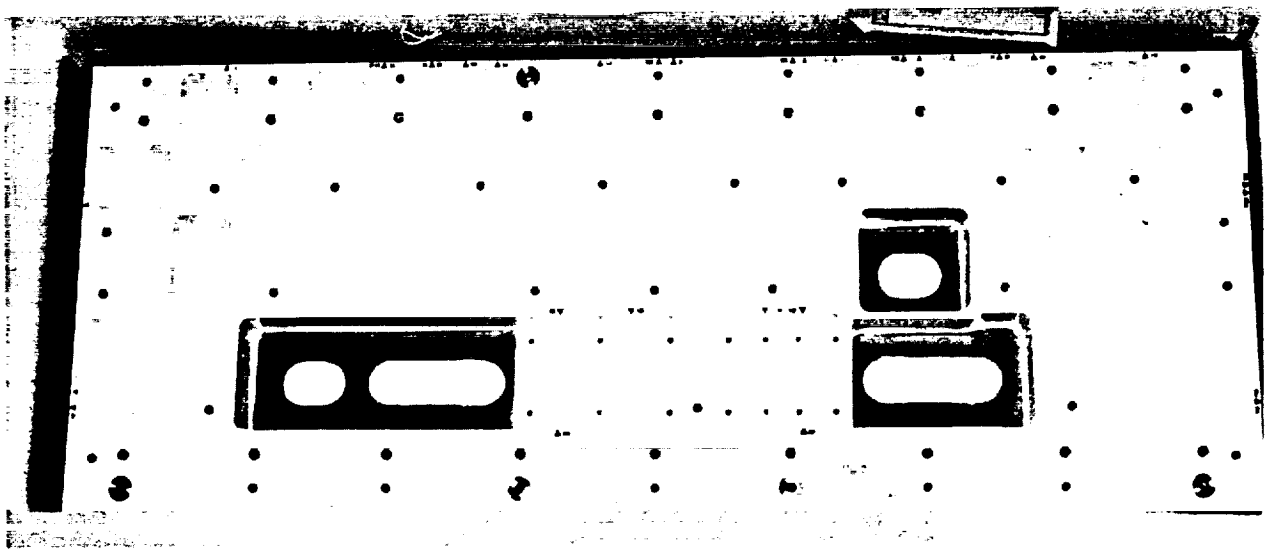
Adaptive Payload Carrier



OVERVIEW

The Adaptive Payload Carrier (APC) was originally designed to mount a Standard Interface Panel (SIP), the APC evolved into a carrier for lightweight payloads that can be mounted in available locations along the sides of the payload bay.

OPERATIONAL COMMENTS AND INTERFACE PROVISIONS

Mounts in 23 positions on each side of the payload bay. Unique port and starboard APC's, which excludes bay 1 and aft section of bay 2.

300 pound load carrying capability, at 6 inch offset, evenly distributed.

STATUS

Successfully flown on a number of STS missions. 16 APC's have been fabricated. (8 port, 8 starboard).

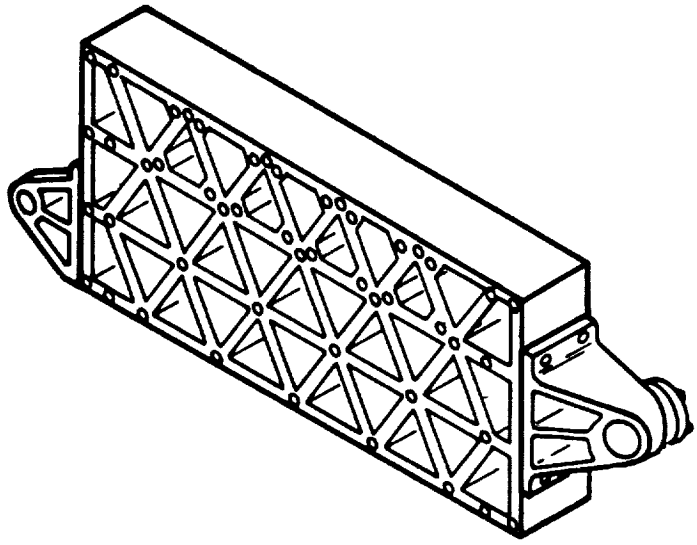
CONTACTS

Source: Rockwell International, 12214 Lakewood Blvd., Downey, CA 90241
Operational: C. W. Anderson, (213)922-5095
R. L. Gasteiger, (213)922-5339

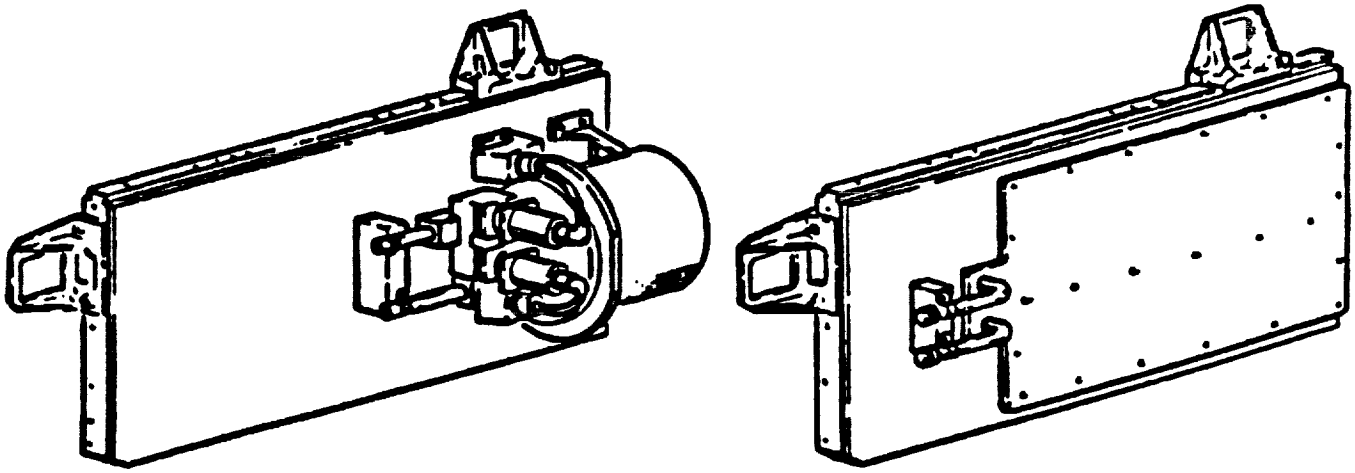
ADAPTIVE PAYLOAD CARRIER

Technical Information	
Weight	26 lbs.
Power Req	N/A
Temp Range	N/A
Cooling	N/A
Material	Aluminum
Status	Flight qualified

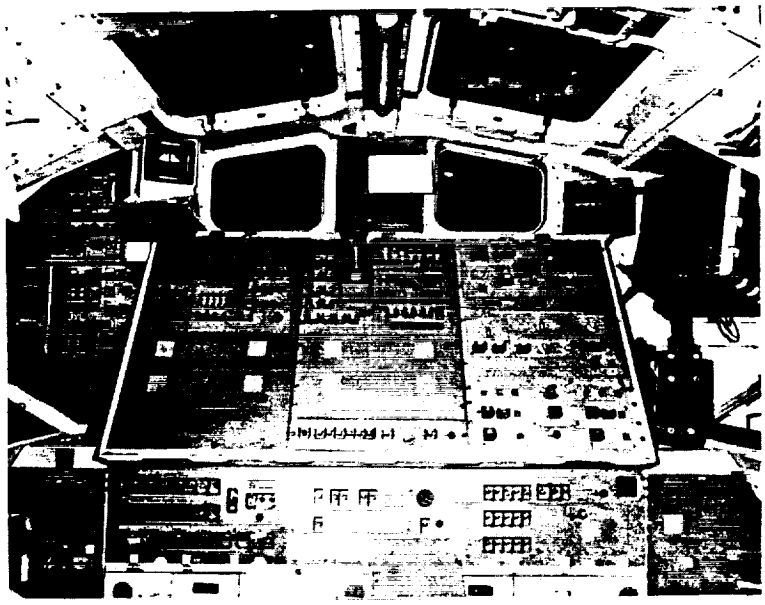
Interface Details	
Electrical	N/A
Mechanical	Attaches to Orbiter main frame, stub frame, and longeron sill
Data Rate	N/A
Documentation	Design Requirements Document STS 81-0302



Possible Coolant Pump and Cold Plate Installation on APC or ICAPC



Aft Flight Deck



S83-37177

OVERVIEW

The Aft Flight Deck (AFD) is the station in the rear of the Orbiter crew compartment from which all payload-related activities are controlled.

OPERATIONAL COMMENTS AND INTERFACE PROVISIONS

Payload display and control panels and equipment are installed in Orbiter-provided removable consoles at the mission station (left) and payload station (right). Panel area for payload display and control is provided near the windows at the on-orbit station (center). Accommodations to install and remove panels in the consoles and in the panel areas are provided as required.

STATUS

The Aft Flight Deck is an integral part of the Shuttle Orbiter.

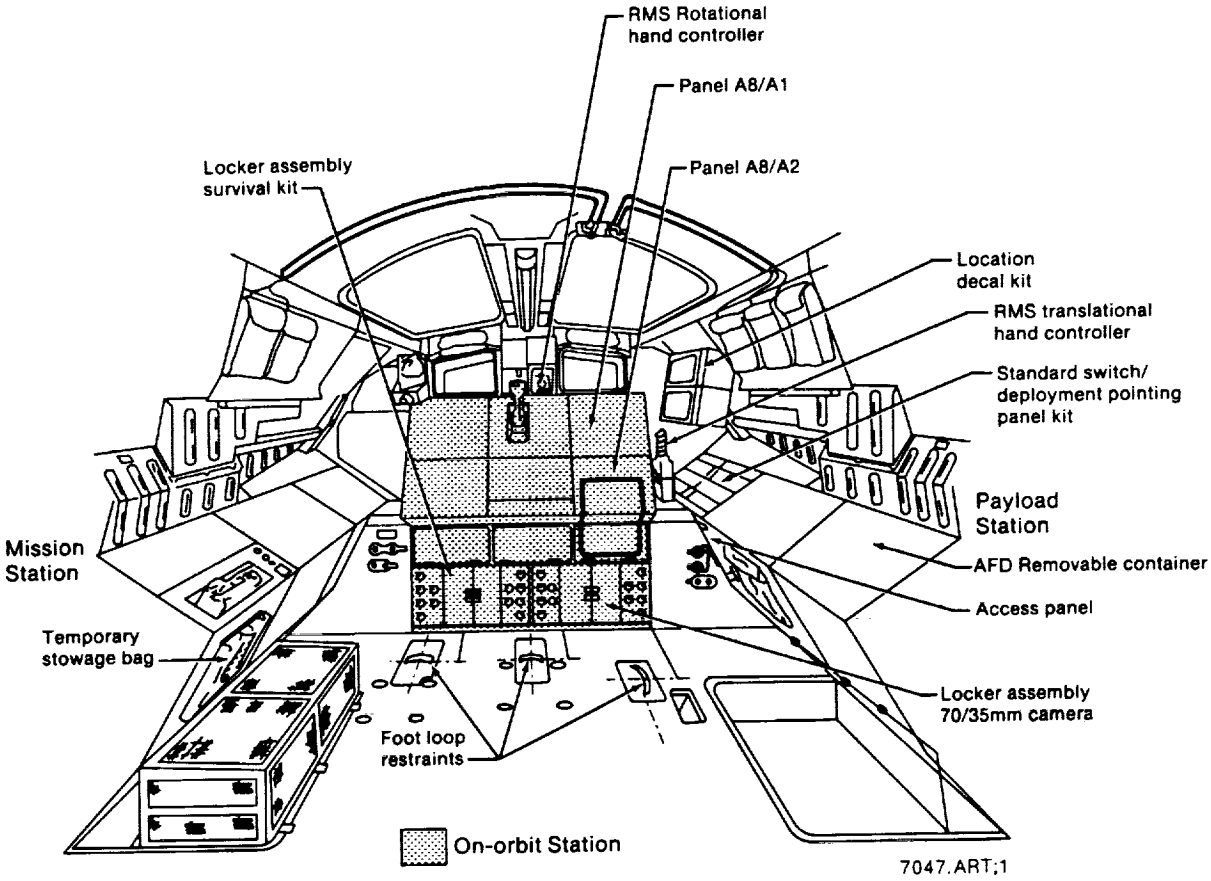
CONTACTS

Source: Rockwell International, 12214 Lakewood Blvd., Downey CA 90241
Operational: Ronald Zaguli, NASA/JSC/DF, (713)483-0887

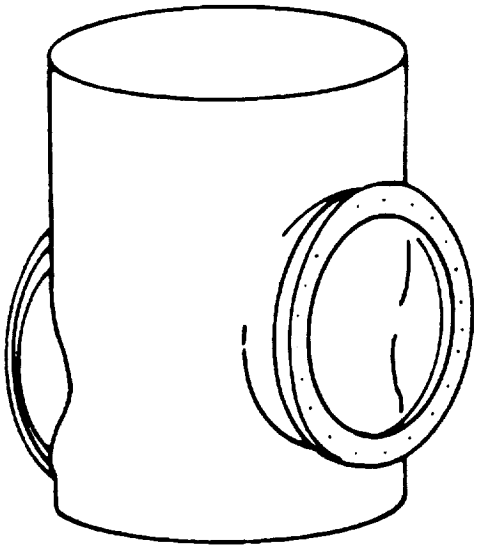
REFERENCES

Shuttle Orbiter/Cargo Standard Interfaces. ICD2-1900.

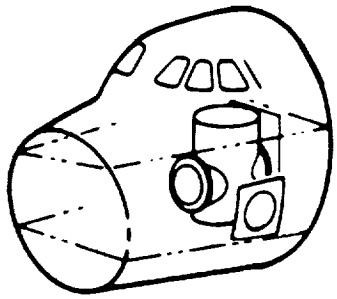
AFT FLIGHT DECK



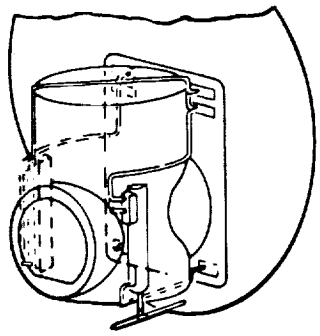
Airlock



Airlock (Exterior View)



Airlock Inside Crew Model



Airlock in Payload Bay

OVERVIEW

The primary purpose of the Airlock is to eliminate the need for cabin decompression for extravehicular activity and to provide a means for transferring between the crew module and the Spacelab or Payload Bay. It may also be used to provide additional volume in the Orbiter Cabin.

OPERATIONAL COMMENTS AND INTERFACE PROVISIONS

In addition to being a compartment which can be depressurized and repressurized to accommodate EVA access to the payload bay, the airlock supports EVA preparation and post EVA activities by providing:

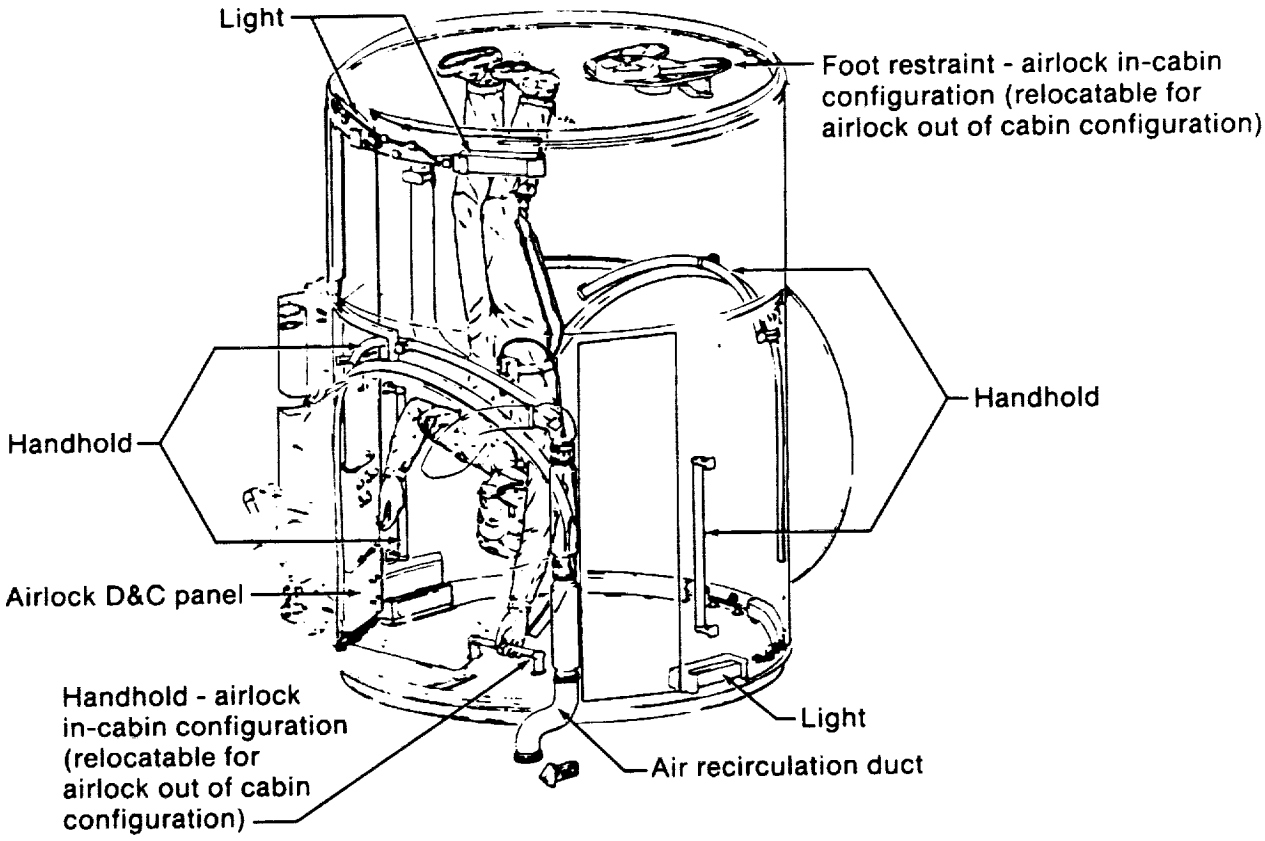
- Handholds and restraints for crewmember translation and position maintenance in zero 'G'.
- Interfaces between the EVA Life Support Systems and the Orbiter Environmental Control and Life Support Systems, and,
- Displays and controls to control all Airlock functions.

STATUS

Flight Qualified.

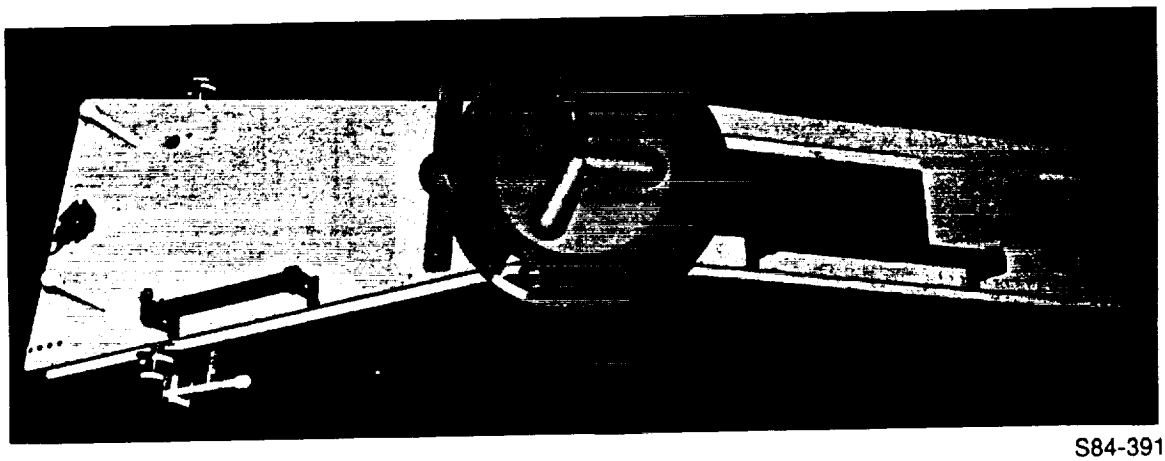
AIRLOCK

Technical Information	
Inside Diameter	63 in.
Length	83 in.
Two D-Shaped Hatches	40 in. in diameter each
Corded side of Hatches	36 in.



Airlock (Interior View)

Antenna Bridge Structure



S84-39126

OVERVIEW

The Antenna Bridge Structure (ABS) was designed to create a framework which distributes remote manipulator system (RMS)-induced forces on a Hughes satellite (HS376). The structure with brackets is approximately 100 inches by 32 inches by 28 inches. The surface of the structure is coated with Chemglaze A276 white paint. It has an RMS grapple fixture and EVA handholds.

OPERATIONAL COMMENTS AND INTERFACE PROVISIONS

The ABS was used on the HS376 retrieval mission. It was designed to be connected to a common bracket and a bumper bracket, which are attached to the satellite first. Velcro holds the ABS in position while connecting it to the brackets. After the ABS is secured, the RMS can maneuver the satellite. The ABS is a payload-unique device and is not normally manifested. It has mounting locations for the antenna cutter and a cut omnidirectional antenna.

STATUS

Flight qualified. Flown on specific STS flights.

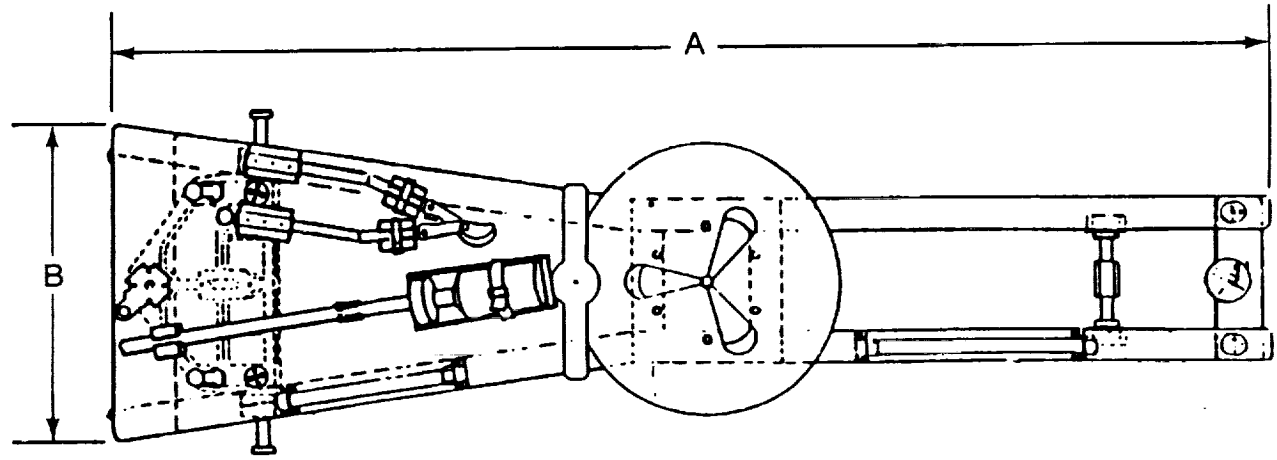
CONTACTS

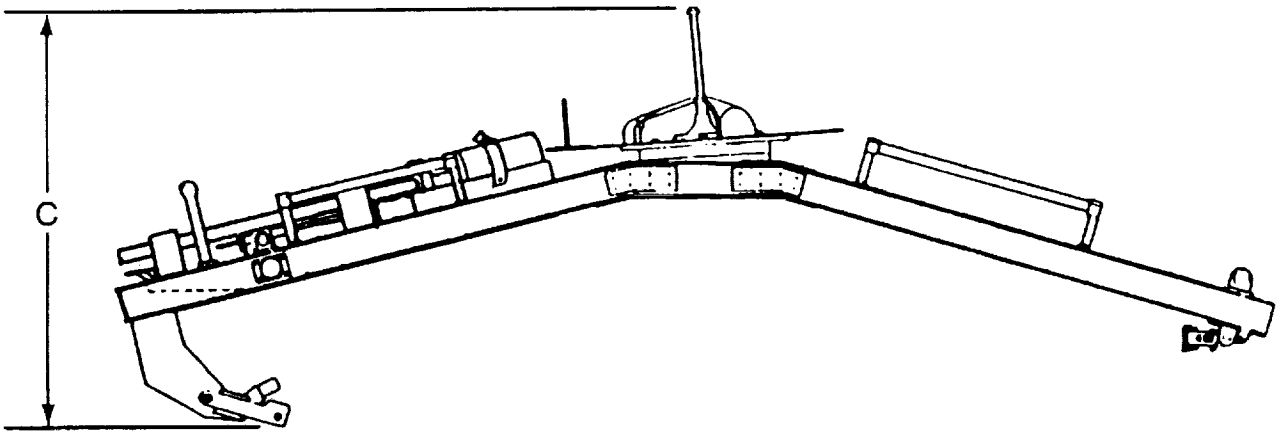
Source: R. C. Trevino, NASA/DG4, (713)483-2597
Operational: C. S. Allton, NASA/EC2, (713)483-9152

ANTENNA BRIDGE STRUCTURE

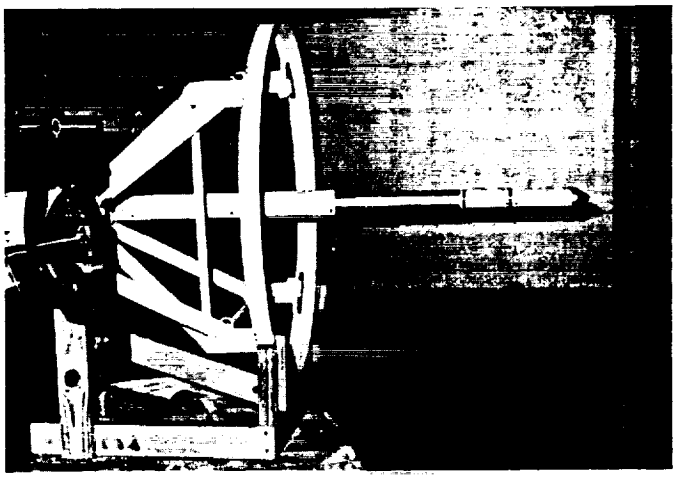
Technical Information	
Part Numbers	SED 39117098
Weight	116.5 lb
Material/ Construction	Aluminum, Chemglaze A276 white paint, EVA handholds, RMS grapple fixture
Temperature Range	-130° to 150° F

Dimensional Data	
A	97 in.
B	26.5 in.
C	36 in.





Apogee Kick Motor Capture Device



S84-42909

OVERVIEW

The Apogee Kick Motor Capture Device (ACD) is a mechanical interface between the Manned Maneuvering Unit (MMU) and the Apogee Kick Motor (AKM) of a Hughes HS 376 satellite. The ACD includes a grapple fixture for use with the Remote Manipulator System (RMS). Two pip pins attach the ACD to the arms of the ACD to the satellite.

OPERATIONAL COMMENTS AND INTERFACE PROVISIONS

The ACD must first be attached to the MMU before the MMU can position the ACD for capture of the satellite. The MMU is used to insert the toggle assembly at the tip of the ACD into the AKM of the satellite. Lines marked on the ACD indicate depth of insertion. Spring-loaded toggle fingers are then released inside the AKM to secure the satellite.

The RMS attaches to the grapple fixture on the ACD and holds the satellite while an Antenna Bridge Structure (ABS) is attached to it. The ACD and MMU are then used to hold the satellite while the RMS moves to the grapple fixture of the ABS. The ACD is then released from the satellite and restowed, using the MMU.

STATUS

Flight qualified. Flown on specific STS flights.

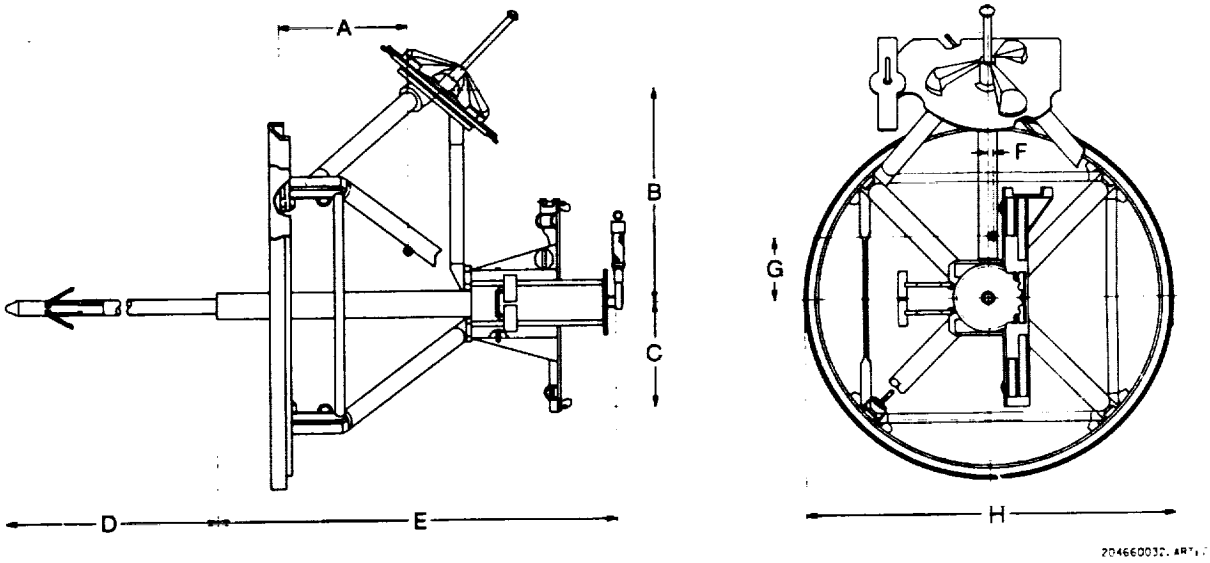
CONTACTS

Source: R. C. Trevino, NASA/DG4, (713)483-2597
Operational: C. E. Whitsett, NASA/EC5, (713)483-9111

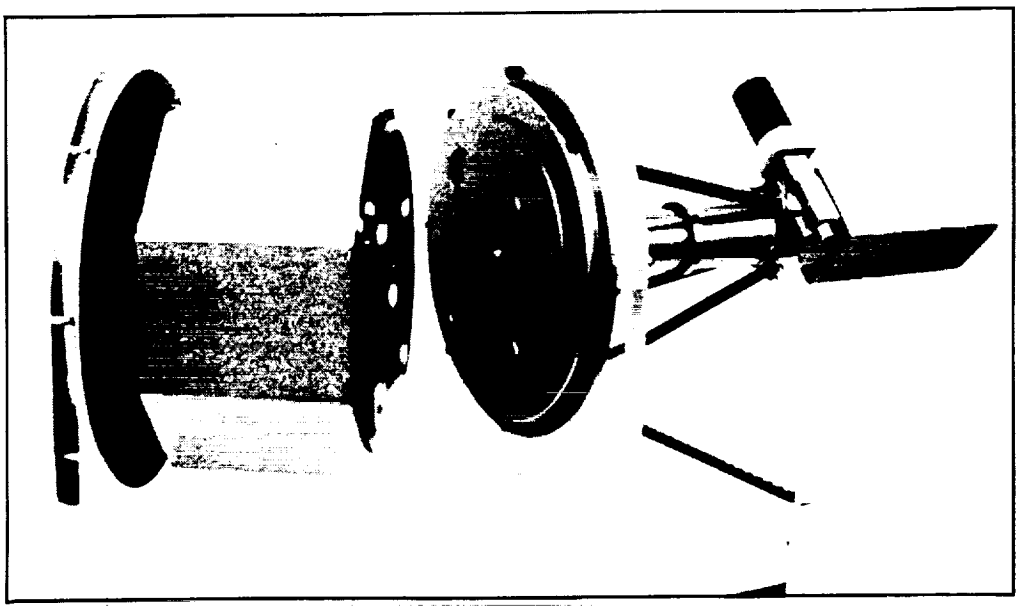
APOGEE KICK MOTOR CAPTURE DEVICE

Technical Information	
Part Numbers	SED 39117132
Weight	128 lb
Material	Stainless steel, aluminum alloy
Major Components	Toggle assembly, control box and retractor, separation ring struts and structure, RMS grapple fixture (trunnion pin attachment device unit)
Design Temperature Range	-130° to 150° F
Quantity Flown	Two for STS-51A
Stowage	Spacelab pallet

Dimensional Data	
A	14.25 in.
B	23.89 in.
C	11.5 in.
D	27 in.
E	44.18 in.
F	0.50 in.
G	6.0 in.
H	41.04



Automatic Umbilical Connector



OVERVIEW

The Moog Automatic Umbilical Connector (AUC), Model 50E559, is a self-contained, fully automatic system capable of making multi-line umbilical connections for spacecraft consumable resupply. The AUC requires only electrical power and input control commands for engage and disengage operations.

OPERATIONAL COMMENTS AND INTERFACE PROVISIONS

The electromechanical actuator is a leadscrew/cam mechanism driven by a 200V line-to-line, 3-phase, 400 Hz electric gear motor. Two Moog rotary shut off disconnects are rigidly attached to the mounting plate. Both disconnects are protected by a rotary circular cover to seal them against contamination when disengaged.

STATUS

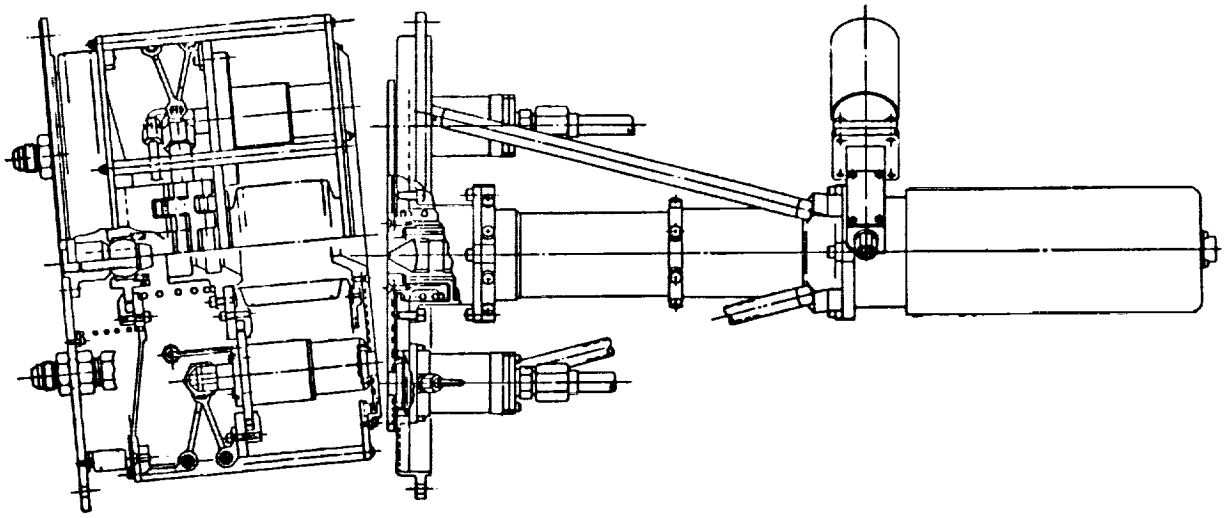
The prototype AUC has been built and tested.

CONTACTS

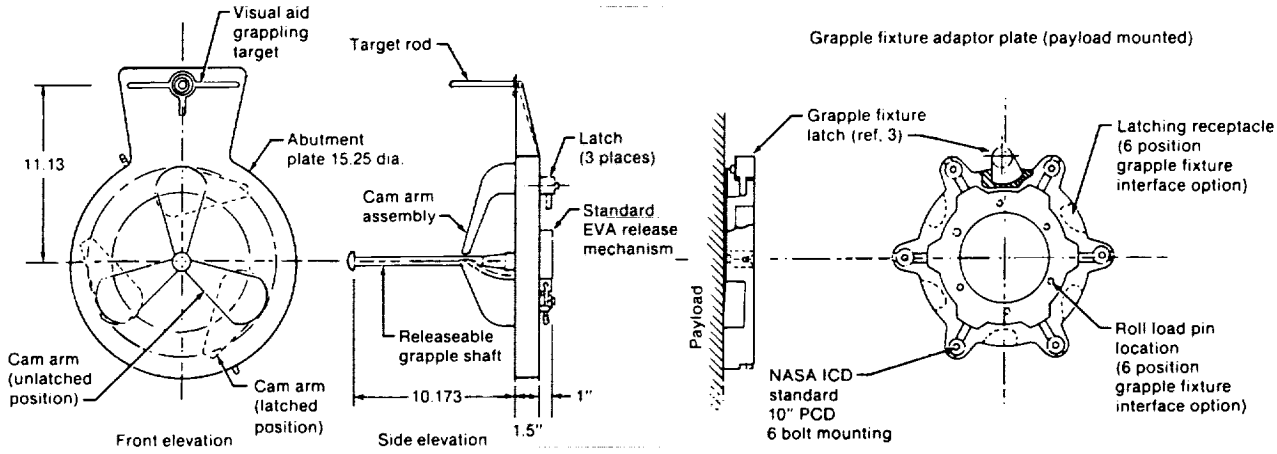
Source: MOOG Space Products Divison
East Aurora, NY 14052
Operational: Joseph M. Cardin, MOOG, (716)667-4417

AUTOMATIC UMBILICAL CONNECTOR

Specifications	
Flow Capacity analogous to 0.50 inch tubing	
Three seals against external leakage when connected	
One seal against external leakage when disconnected	
Seal verification and purge ports	
Plug compatible with like units	
Cycle Life	1,000 connects/ disconnects minimum
Wetted Materials	CRES, Teflon, EPR
Compatibility	H_2O, GN_2 , Hydrazine
Misalignment Envelope	Pitch & Yaw ± 5.0° Roll ± 1.0° X + 0.125 in. Y, Z ± 0.125 in.



Auxiliary Grapple Fixture



OVERVIEW

The Auxilliary Grapple Fixture (AGF) offers a means to attach a Grapple Fixture to a payload on-orbit and thereby permit the Shuttle Remote Manipulator System to handle the payload.

OPERATIONAL COMMENTS AND INTERFACE PROVISIONS

To provide the means to attach the AGF on-orbit a small, low weight adapter plate is installed onto the payload prior to flight via the standard grapple fixture bolted interface. On-orbit EVA attachment of an AGF is achieved by rotating three cams on the rear face of the AGF which engage with cut-outs on the adapter plate.

The cams are rotated into the locked position by rotating the End Effector location cams on the front face of the grapple fixture. The adapter plate has six cut-outs for cam engagement which allow the AGF to be attached in any of six angular orientations.

The AGF is manufactured using the same lightweight construction approch used for the Lightweight Grapple Fixture. The adapter plate permanently attached to the payload provides an extremly small weight and envelope penalty to a payload which may require a Grapple Fixture for contingency operations.

EVA release has been designed as a standard feature and an electrical interface option between the AGF and the End Effector may be accommodated.

STATUS

Conceptual design, patent applied for. Under development and a possible consideration for future use by NSTS.

CONTACTS

Source: Spar Aerospace Limited, 1700 Ormont Dr. Weston, Ontario Canada MGL-2W7
Operational: B. Hill Spar/(416)745-9680

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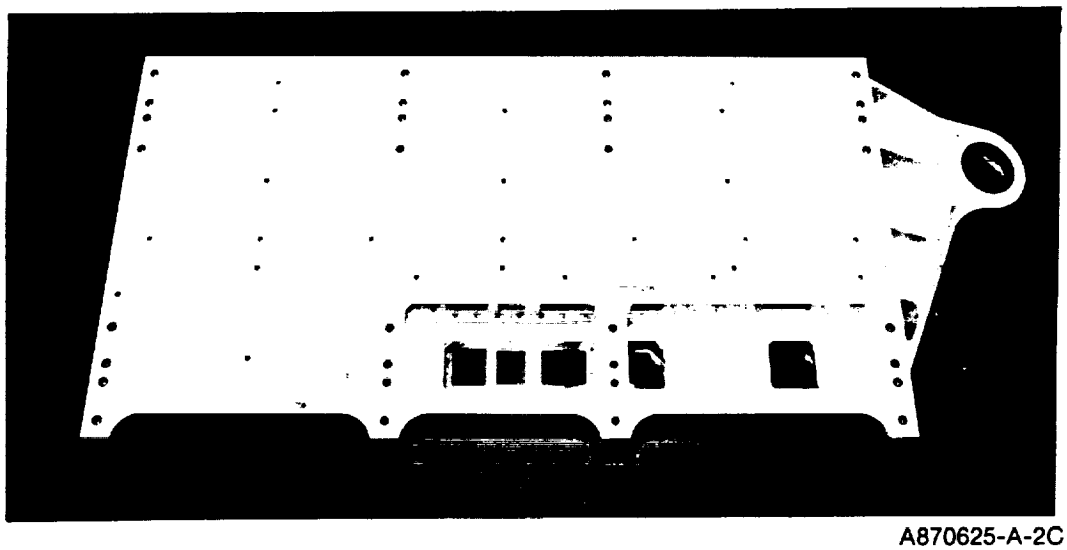
Bridge Payload Carrier



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OVERVIEW

The Bridge Payload Carrier (BPC), commonly known as the GAS bridge, was originally designed to carry multiple Getaway Special (GAS) canisters.

OPERATIONAL COMMENTS AND INTERFACE PROVISIONS

Mounts in bays 2 through 8, unique BPC for 14 locations (7 port and 7 starboard).

800 pound load carrying capability

STATUS

Successfully flown on most STS missions.
Units fabricated 10 - (5 Port, 5 Starboard)
10 - for Starboard, bays 2, 3 & 4 only
1 - Bay 12, starboard (special build)

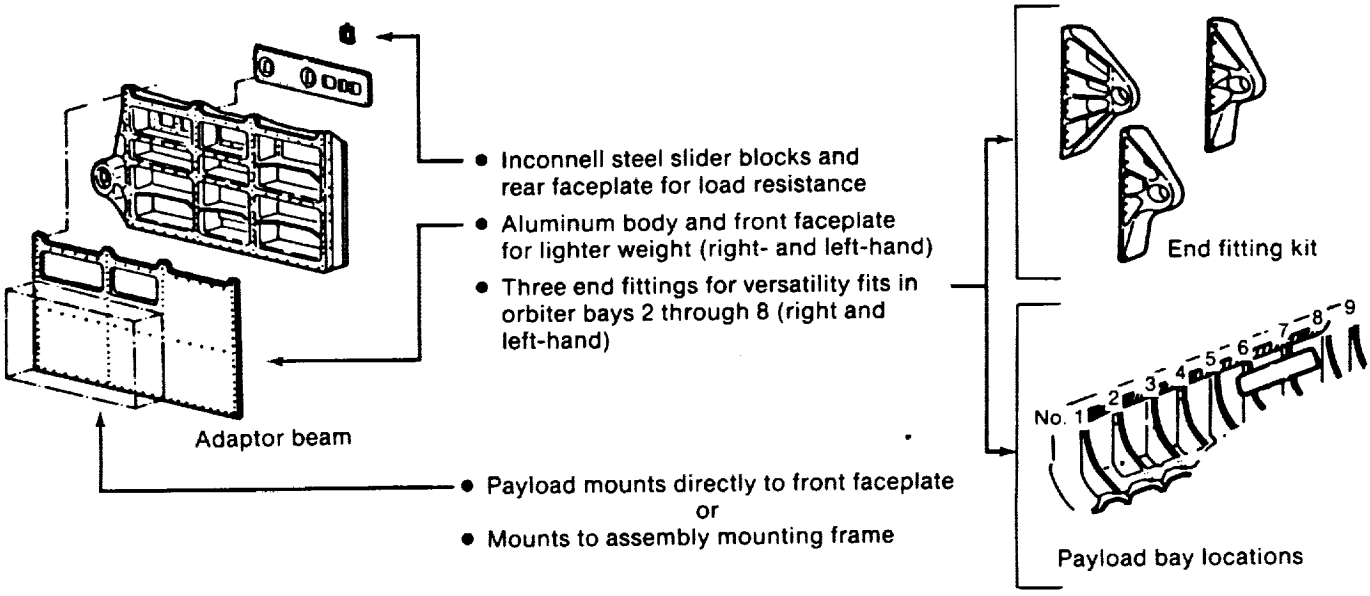
CONTACTS

Source: Rockwell International, 12214 Lakewood Blvd., Downey, CA 90241
Operational: C. W. Anderson, (213)922-5095
R. L. Gasteiger, (213)922-5339

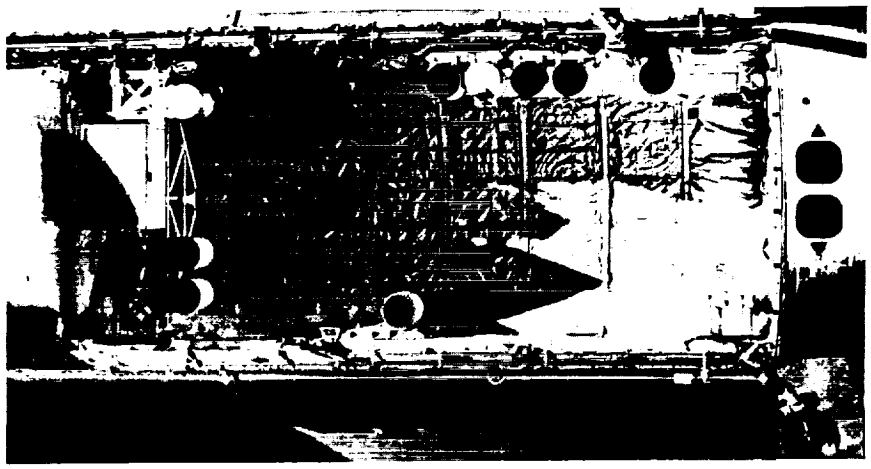
BRIDGE PAYLOAD CARRIER

Technical Information	
Weight	155 lbs.
Power Req	N/A
Temp Range	N/A
Cooling	N/A
Material	Aluminum and Inconel
Status	Flight qualified

Interface Details	
Electrical	N/A
Mechanical	Attaches to two main frames and longeron sill See ICD - 2 - 19001 and ICD - A - 14021
Data Rate	N/A
Documentation	Design Requirements Document STS79-0695A



Cargo Bay Envelope



S83-35804

OVERVIEW

The Cargo Bay of the Space Shuttle Orbiter consists of an envelope which is 15 ft. in diameter and 60 ft. in length; it is designed to accommodate a variety of different payloads. Because it houses the payloads, it is also called the Payload Bay.

OPERATIONAL COMMENTS AND INTERFACE PROVISIONS

The Cargo Bay envelope is the designated volume within which all payloads, payload protrusions, and payload deflections must be contained. Payloads or payload protrusions outside of this volume may interfere with Cargo Bay door operation and Cargo Bay vision requirements. The Cargo Bay payload attach points are outside of the envelope and payload attach fittings may extend outward to reach these points. Umbilicals required to interface the payload with the Orbiter may also penetrate the envelope. The user must make allowances for, and surrender volume to, Orbiter-related hardware which protrudes into the envelope. A minimum clearance of 3 in. is required between cargo elements and the Orbiter-related hardware.

STATUS

The Cargo Bay is an integral part of the Shuttle Orbiter.

CONTACTS

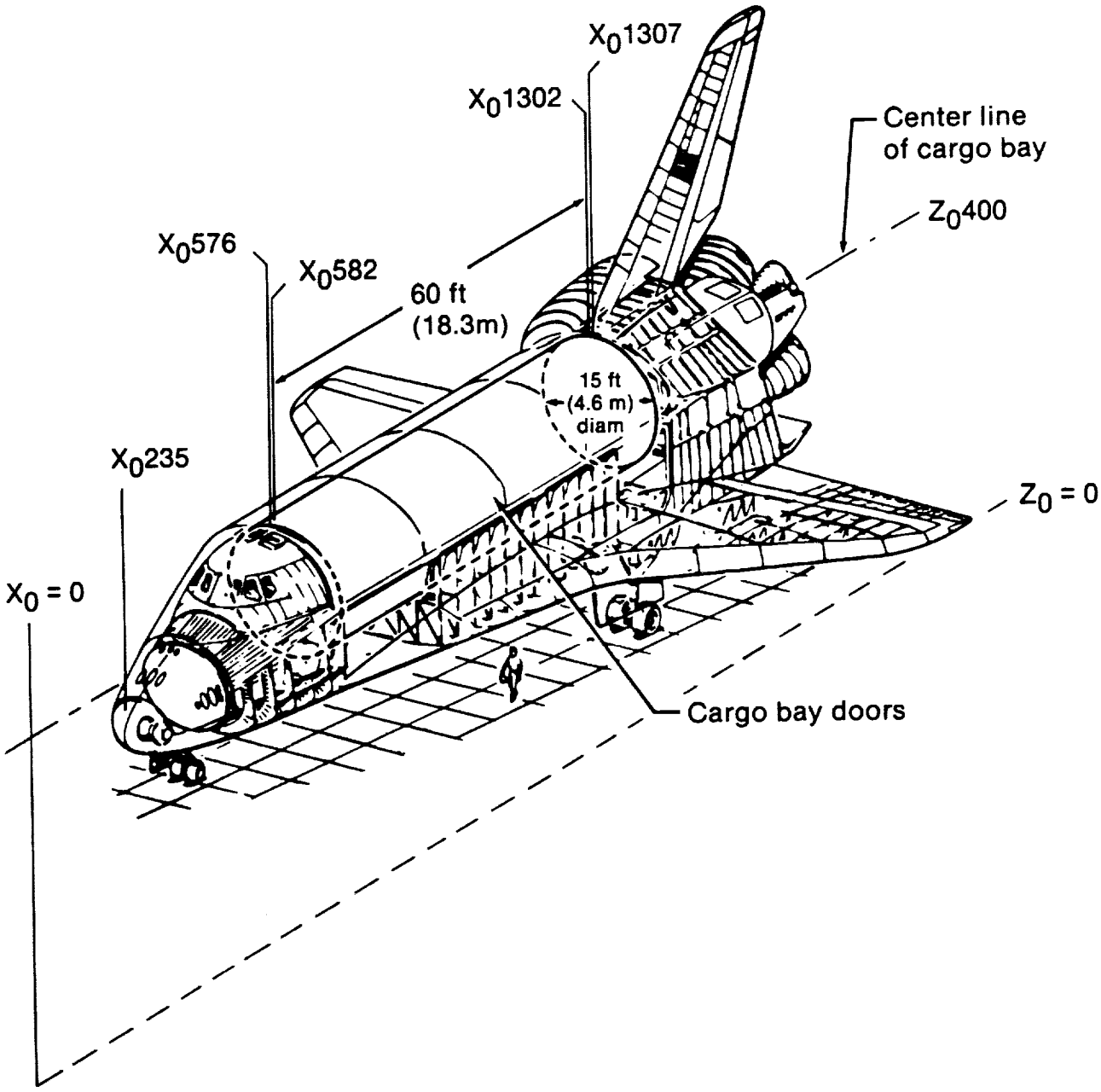
Source: Rockwell International, 12214 Lakewood Blvd., Downey, CA 90241
Operational: Robert Adams, NASA/JSC/DF, (713)483-2567

REFERENCES

Level II Program Definition and Requirements, Vol. 14, Space Shuttle System Payload Accommodations, Rev. G, Attachment 1. JSC-07700, ICD-2-19001, May 1983.

CARGO BAY ENVELOPE

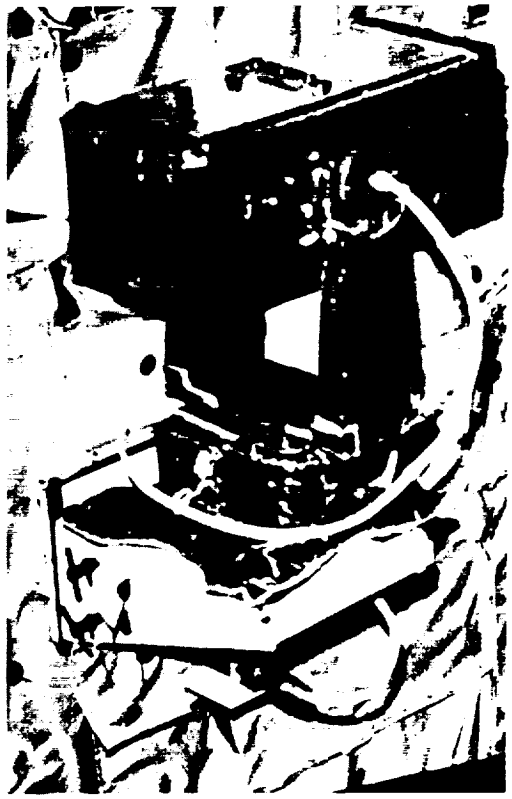
Specifications	
Length	60 ft.
Diameter	15 ft.
Volume	~10,600 ft^3



Closed Circuit Television

OVERVIEW

The Closed Circuit Television (CCTV) system is used primarily to support on-orbit activities which require visual feedback to the crew. The CCTV system also provides the capability to document on-orbit activities and configurations for permanent record or for real-time transmission to the ground. The CCTV system can be controlled both onboard and remotely by uplink commands.



S82-27664

OPERATIONAL COMMENTS AND INTERFACE PROVISIONS

The CCTV system is a standard monochrome (black and white) system which utilizes a color filter wheel to provide color capability. Color scenes are not available on the onboard monitoring because of hardware restrictions; they are available, however, on recorded and downlinked video.

Video inputs to the CCTV system are available from Cargo Bay bulkhead and keel cameras, Remote Manipulator System cameras, pallet-mounted cameras, and crew cabin cameras. Video outputs can be assigned to onboard TV monitors, to the onboard video tape recorder, or to any payloads with TV capability; output can also be downlinked to the ground.

The CCTV system is typically used to monitor and record mission activities such as Cargo Bay door operations, Remote Manipulator System camera output, experiment operations, rendezvous and stationkeeping operations, and onboard crew activities. Inspection of the Orbiter Cargo Bay and the Orbiter exterior, along with inspection of other on-orbit vehicles, constitutes another important use of the CCTV system.

The CCTV system consists of the following major components:

(1) Video control unit - An interleave capability exists with audio channels A and B; multiplex capability is available for split screen. Remote command control of the camera lens and the pan/tilt functions, by both the crewman and the ground, is available. Eleven video inputs and five outputs are available for independent selection.

(2) Television cameras - A choice of lens assembly provides selection of either color or black and white. The Cargo Bay camera pan and tilt capability is ±170° at the rate of 1.2°/sec or 12°/sec. Zoom capability is either 30° to 80°, horizontal field of view, or 6.5° to 39°.

(3) Video Tape Recorder - Record capability is 30 min (increased to 72 min on later missions); monochrome or National Television Standards Committee (NTSC) color is available.

(4) Television monitors - Two black-and-white 8-in.-diagonal displays are provided.

STATUS

Flight qualified. Flown on specific STS flights.

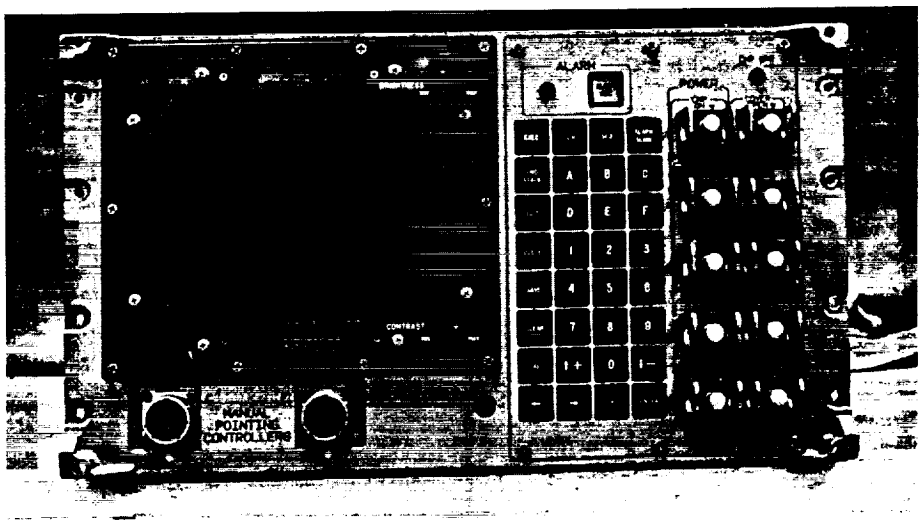
CONTACTS

Source: RCA, NASA/JSC
Operational: David R. Brooks, NASA/JSC/DF, (713)483-2565

REFERENCES

Close Circuit Television

Command and Monitor Panel



OVERVIEW

The Command and Monitor Panel was designed to provide a man/machine interface to monitor and control payloads from the aft flight deck of the Orbiter. However, it could also be used as a standard monitor and control device for satellites while they are being serviced by the Orbiter.

OPERATIONAL COMMENTS AND INTERFACE PROVISIONS

The Command and Monitor Panel consists of a computer, CRT display, two joysticks, keyboard, hardline toggle switches, and interface connections. Functional capabilities include monitoring, command, control, telemetry link, and other satellite-unique features as required. It is equipped with a Command and Telemetry Interface Unit which can input/output a variety of both analog and digital data.

STATUS

The Command and Monitor Panel was developed by the Lockheed Missiles and Space Company (LMSC). A flight-qualified version has flown on the Shuttle.

CONTACTS

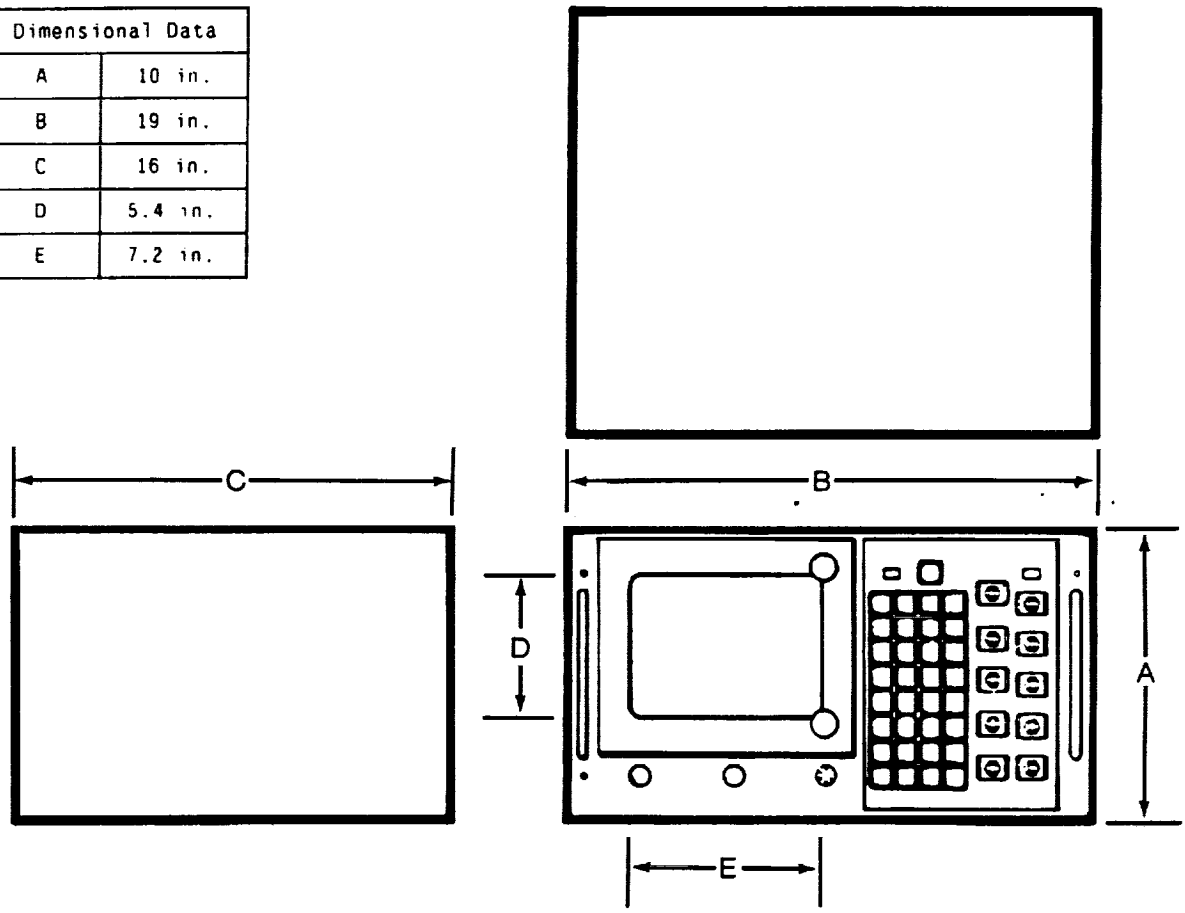
Source: LMSC, 1111 Lockheed Way, Sunnyvale, CA 94089-3504
Operational: LMSC, Jack Wohl, (408)743-1690

COMMAND AND MONITOR PANEL

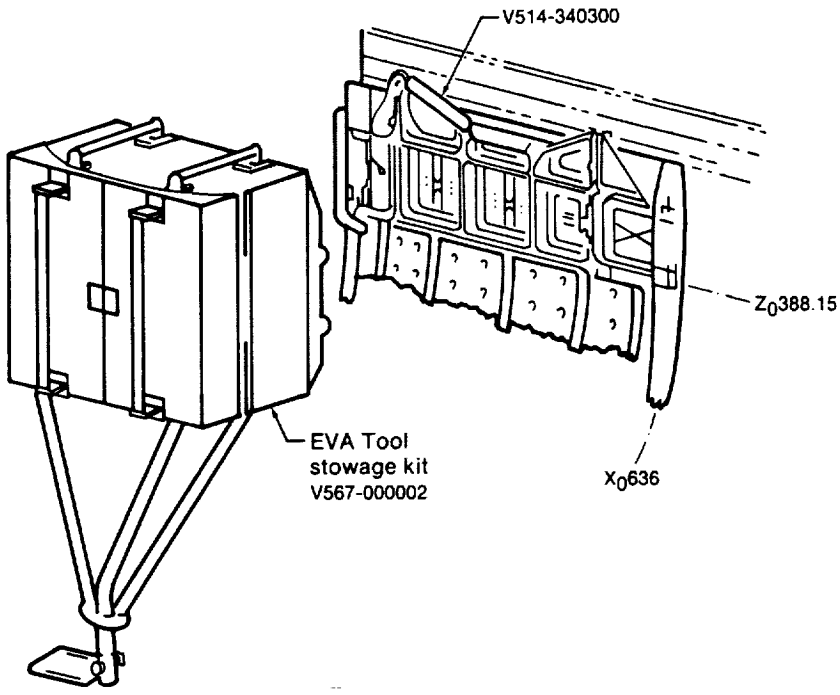
Technical Information	
Weight	70 lb
Power Req.	180 Watts
Temperature Range	+30° to +125° C
Cooling	Orbiter air duct fitting
Material	Structure-aluminum
Status	Flight qualified

Interface Details	
Electrical	Standard mixed cargo Harness
Mechanical	Uses 1/2 Orbiter payload console
Data Rate	Multiple formats 256 kbps
Documentation	Interface control document Available

Dimensional Data	
A	10 in.
B	19 in.
C	16 in.
D	5.4 in.
E	7.2 in.



Containerless Support Assembly



OVERVIEW

The Containerless Support Assembly (CSA) is designed to carry the cargo bay storage assembly used for storage in the payload bay.

OPERATIONAL COMMENTS AND INTERFACE PROVISIONS

CSA for bay 1 port or starboard.

400 lb. load carrying capability at 11 inch offset.

CSA for bay 2 through 6 (port and starboard assemblies)

400 lb. load carrying capability at 11 inch offset.

STATUS

Flown on a number of STS missions
Four (4) units fabricated for Bay 1
Four (4) units (2 Port, 2 Starboard) fabricated for Bays 2-6

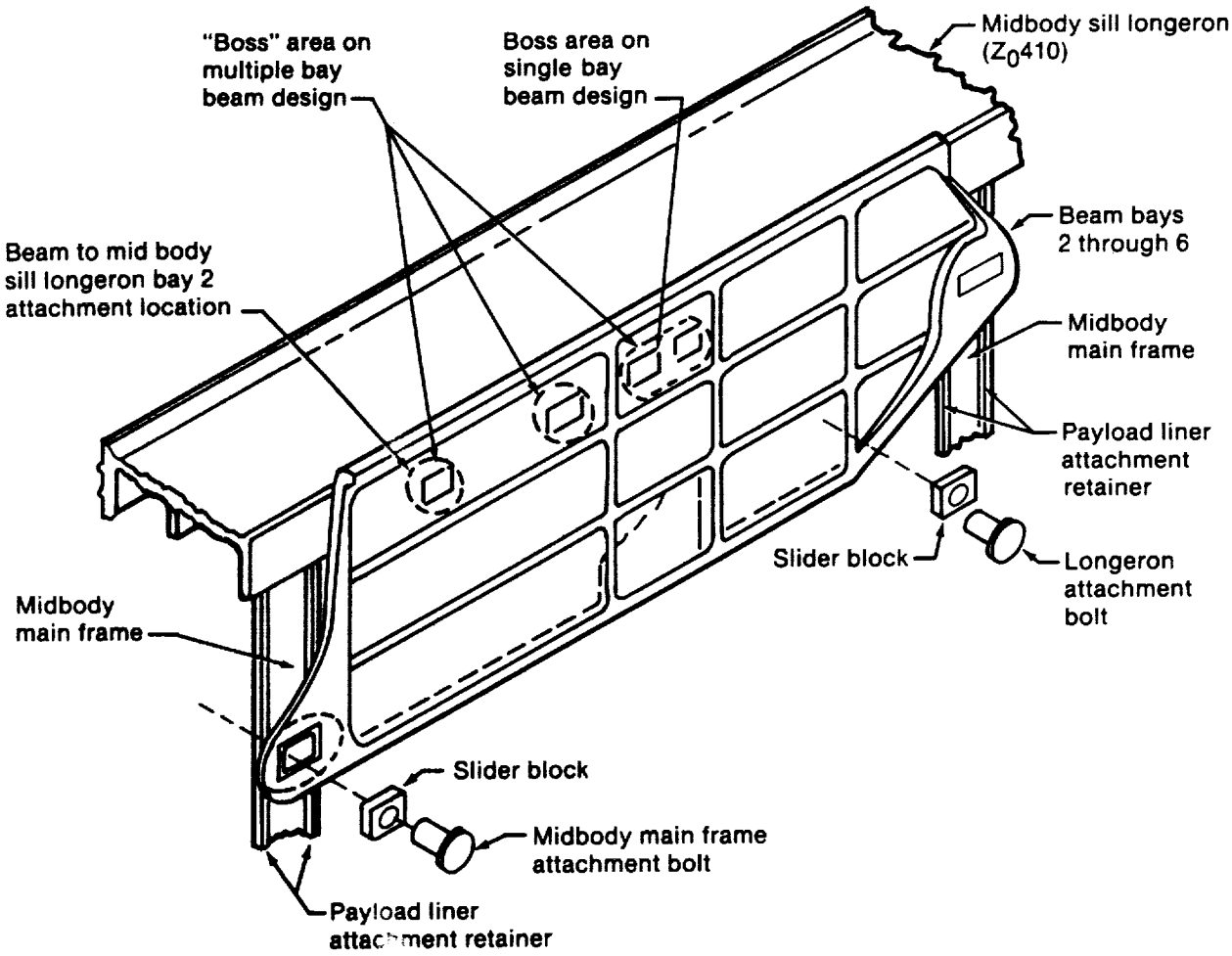
CONTACTS

Source: Rockwell International, 12214 Lakewood Blvd., Downey, CA 90241
Operational: C. W. Anderson, RI, (213)922-5095
R. L. Gasteiger, RI, (213)922-5339

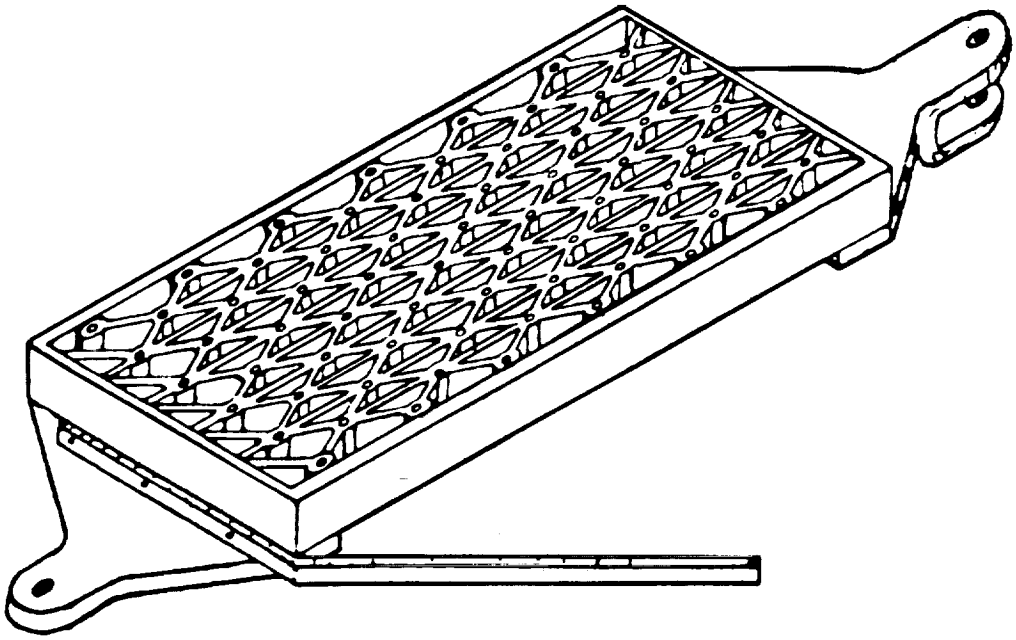
CONTAINERLESS SUPPORT ASSEMBLY

Technical Information	
Weight	CSA (bay 1) 45 lbs, CSA (bay 2-6) 75 lbs.
Power Req	N/A
Temp Range	N/A
Cooling	N/A
Material	Aluminum
Status	Flight qualified

Interface Details	
Electrical	N/A
Mechanical	Attaches to two orbiter main frames and longeron sill
Data Rate	N/A



Delta Keel Payload Carrier



OVERVIEW

The Delta Keel Payload Carrier (DKPC) was conceived to "Fill the Gap" in the Orbiter payload carrying capability when the side loaded payloads (i.e., Adaptive Payload Carrier - APC, Bridge Payload Carrier - BPC, or the Extended APC - EAPC) are installed, leaving the center part of the cargo bay open for payload use.

OPERATIONAL COMMENTS AND INTERFACE PROVISIONS

- Attaches to Keel Bridge Locations & Orbiter Scar Attach Points
- Uses Orbiter Keel Bridge Attach Hardware
- Single Design Fits All Bays
- Isogrid Structure Provides Many Potential Payload Attach Points

STATUS

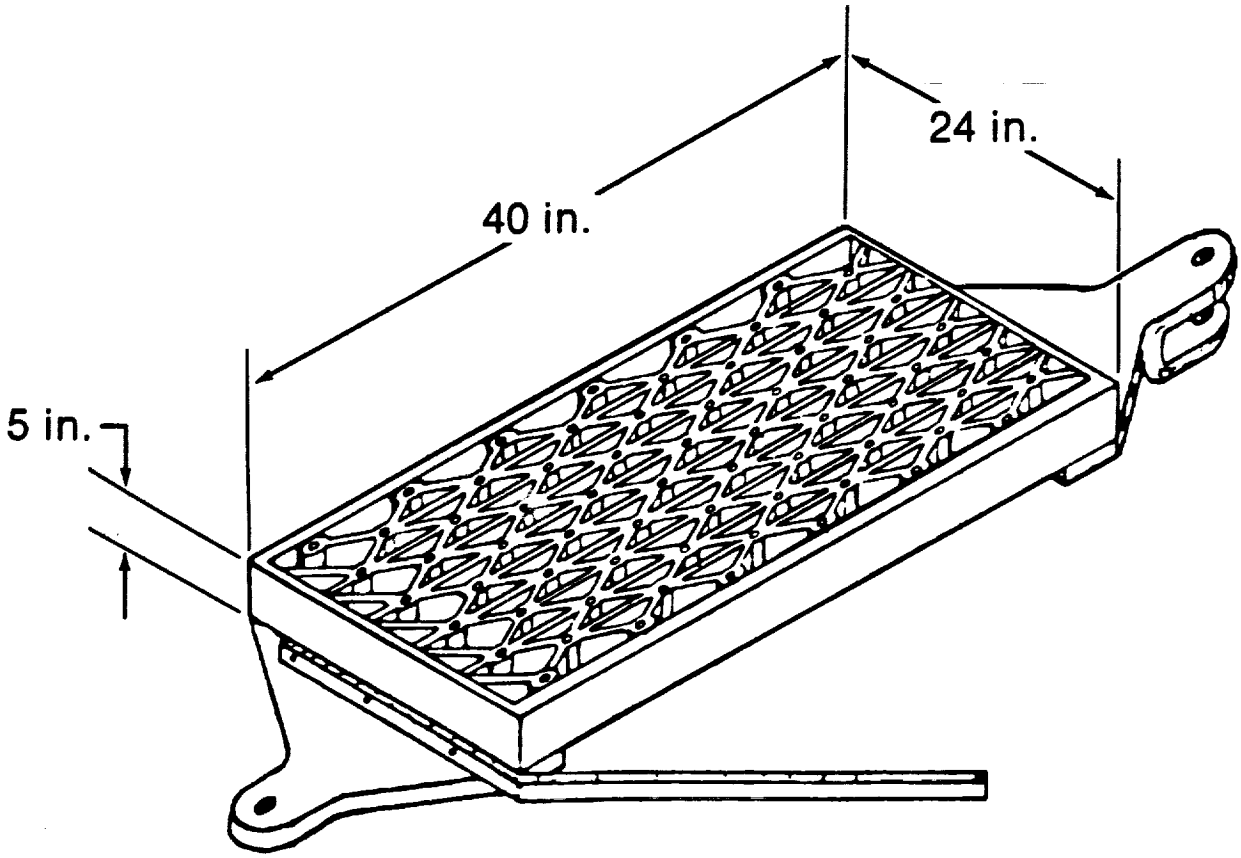
Concept

CONTACTS

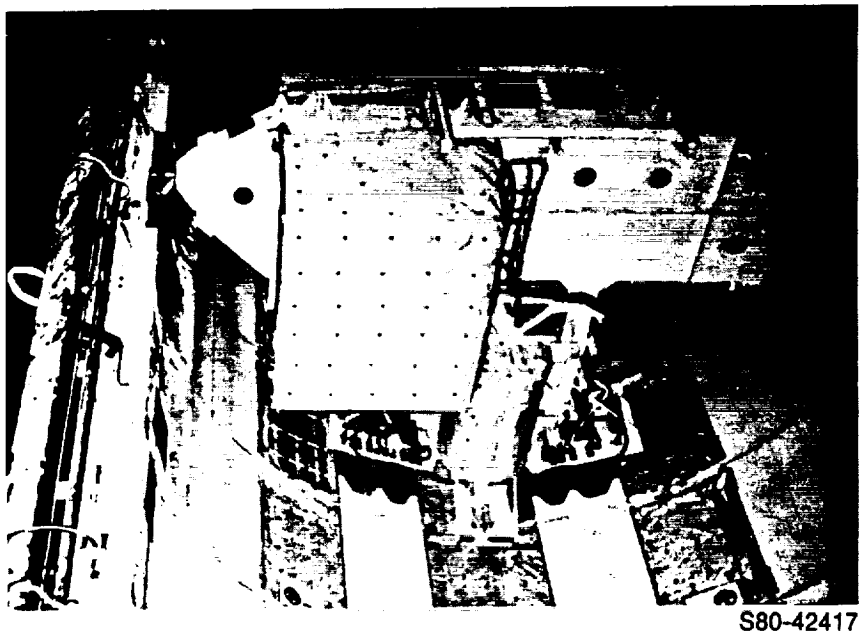
Source: STS Users Center, Rockwell International, Space Business, 12214 Lakewood Boulevard, Downey, CA 90241, (213)922-3344
Operational: R. L. Gasteiger, (213)922-5339

DELTA KEEL PAYLOAD CARRIER

Technical Information Design Goal	
Weight	<150 lbs.
Load Design	2000 lbs.
Size	24" x 40"
Load Carrying Capability by Bay	
Bay 1	250 lbs.
Bay 2	550 lbs.
Bays 3 & 4	1000 lbs.
Bays 5,6,7 & 12	1500 lbs.
Bays 8,9,10 & 11	2000 lbs.



Developmental Flight Instrumentation Carrier



S80-42417

OVERVIEW

The Developmental Flight Instrumentation (DFI) Carrier is a reusable equipment support structure which can be mounted in any one of several places within the Orbiter Cargo Bay.

OPERATIONAL COMMENTS AND INTERFACE PROVISIONS

The DFI Carrier structure is T-shaped, with trunnions at the ends of the upper structure and a keel fitting at the lower end. Payload elements are attached to the structure by means of several clevis-type fittings arrayed to carry components along the front and rear faces of the carrier. In addition, a shelf is fitted to the top surface to accommodate additional elements. The passive trunnion and keel fittings are unique to the carrier structure.

STATUS

Four developmental units were flight qualified through STS-8.

CONTACTS

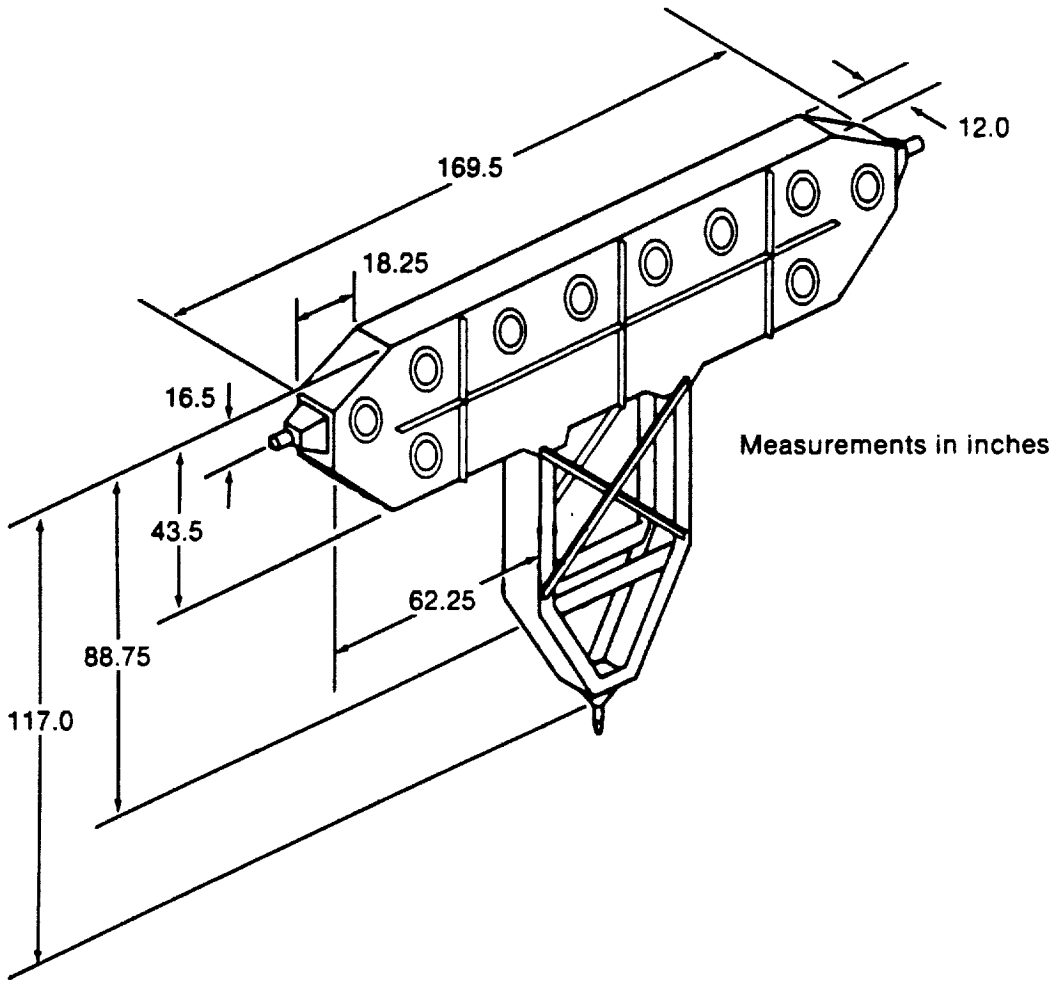
Source: Rockwell International
Operational: Larry P. Ratcliff, JSC/ES6, (713)483-8943

REFERENCES

DFI Container Tech Order. M 072-340034.

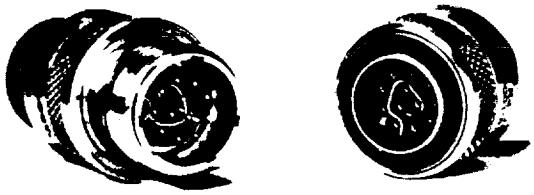
DEVELOPMENTAL FLIGHT INSTRUMENTATION CARRIER

Technical Information	
Dimensions	See drawing
Weight	1,700 lb Maximum attachable weight: 6,000 lb



Electrical Connectors, G&H Family of Connectors

Large

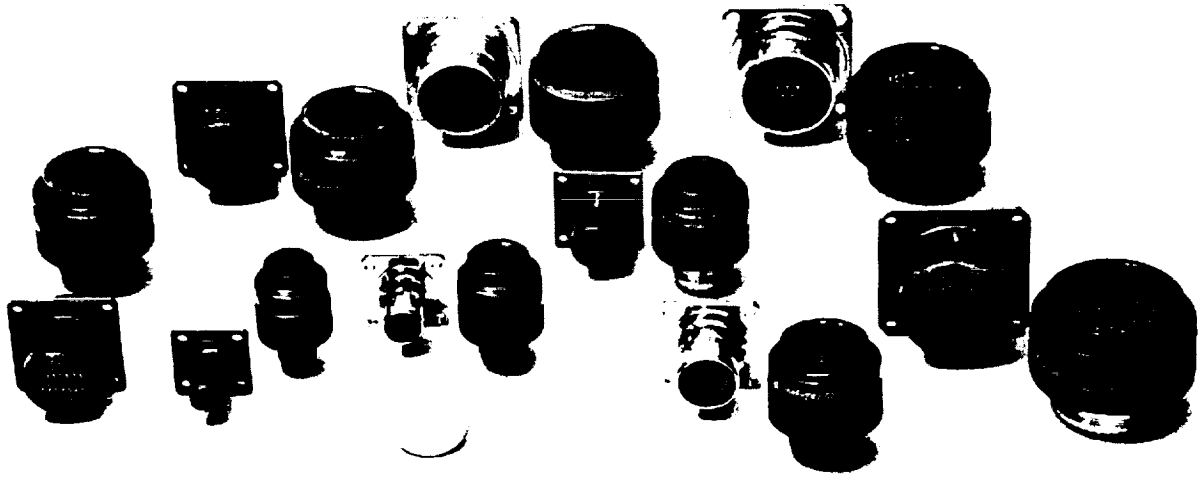


Small

Medium

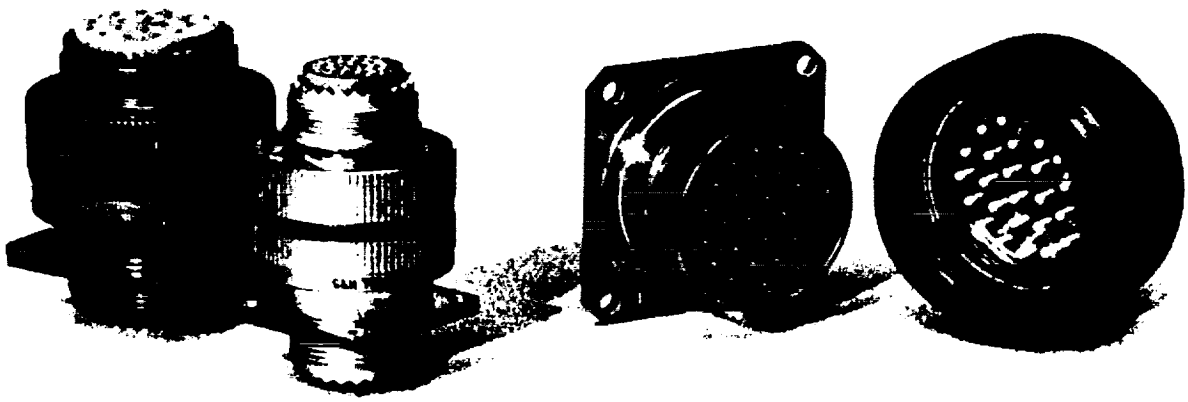
G&H Model 870 Cryogenic Electrical Family

Positive Mate Monitor Family of Connectors



Breech-Lok® MIL-C-38999 Family of Connectors

Electrical Connectors, G&H Family of Connectors



Breech-Lok® MIL-CX-38999 with Fiber Optic Termini

OVERVIEW

The above G&H family of electrical connectors are available either as a complete family or as components of any given family.

OPERATIONAL COMMENTS AND INTERFACE PROVISIONS

G&H family of connectors provides for various interconnect functions such as:

1. Electrical circuits (contact size)
   (a) 22 gage, 20 gage, 16 gage, 8 gage, RG 122/U, RG 142, RG 393, as well as Size 8 coax, triax and data bus contacts. Litz Power Cable contacts are also included.

2. Fiber Optic
   (a) Equivalent contact sizes are 16 gage-Fiber Size 125-625 micron

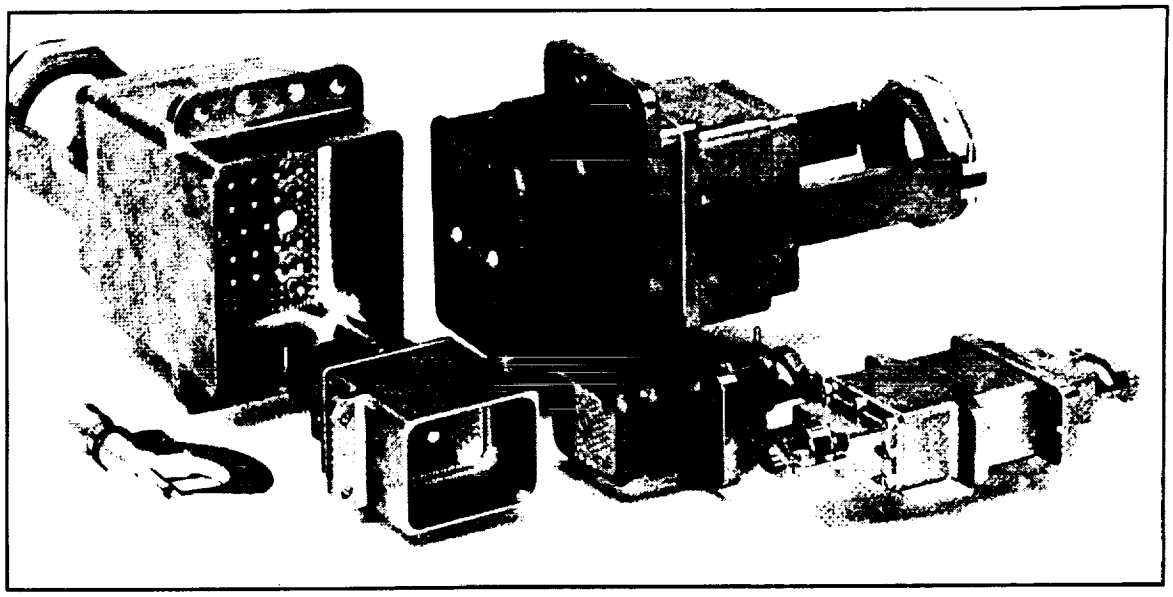
STATUS

Many of the G&H Family of Connectors have been designed to NASA specifications and have flown on various space vehicles.

CONTACTS

Source: G&H Technology, Inc., 1649 17th Street, Santa Monica, CA 90404
Operational: Earl Cooper, G&H, (213)450-0561

Electrical Connectors, G&H Model 882 Family



OVERVIEW

The G&H Model 882 Family of Electrical Connectors are designed to be used by astronauts in EVA, in a shirt sleeve environment and eventually by remote manipulators. Therefore, these connectors are designed for operational ease.

OPERATIONAL COMMENTS AND INTERFACE PROVISIONS

The design characteristics of the Model 882 Family of Connectors consist of the following elements:

(1) Self Aligning

Engage without visual aid. Referred to as Blind Mate Capability.

(2) Scoop Proof

The Circuit components (Electrical contacts, valves, etc.) must be protected from damage during the self aligning (Blind mate) portion of the connector engagement sequence.

(3) Low Force

The force required to complete the connector engagement and disengagement sequence must be as low as possible.

(4) Full Connector Engagement Position Maintenance

Maintained by means of a self locking, easy to release self contained mechanism.

(5) Antibind Rolloff

Prevents connector plug shell to receptacle shell binding when the connector is subjected to side or moment loading during the engage or disengage motion.

(6) Full Mate Feedback

Electrical or mechanical indication that the connector is fully mated.

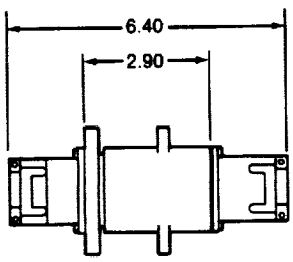
STATUS

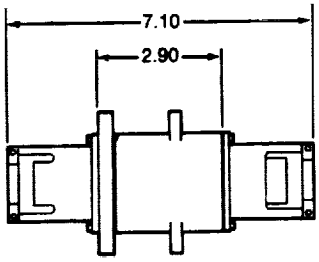
Flight qualified. A Model 882 connector was returned to earth from the Solar Max Recovery Mission.

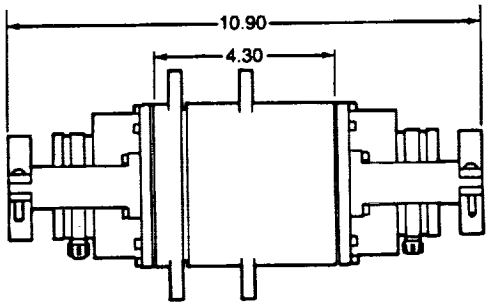
CONTACTS

Source: G&H Technology, Inc., 1649 17th Street, Santa Monica, CA 90404
Operational: Earl Cooper, G&H, (213)450-0561

Specifications	
Blind Mate-Self Aligning	Engagement accomplished with angular misalignment of up to ±10° and lateral misalignment of up to ±12".
EMI/EMP Protection	Better than 60db attenuation from 15KHz to 1,000MHz and decreasing linearly from 1,000MHz to 40db @ 10GHz.
Low Outgassing	Less than 1% TML and ≤0.1% CVCM.
Insulation Resistance	1,000 Megohms contact to contact or contact to shell.
Dielectric Withstanding Voltage	1,500 VDC contact to contact or contact to shell.
Vibration	20G's from 10HZ to 2Khz.
Physical Shock	Per MIL-STD-202, method 213, condition G
Temperature Range	-55°F to +250°F operating range.
Thermal Shock	Per MIl-STD-202, method 102, condition C.
Salt Spray	Per MIl-STD-202, method 101, condition B.
Moisture Resistance	Per MIl-STD-202, method 106.
Durability	250 mate and unmate cycles.



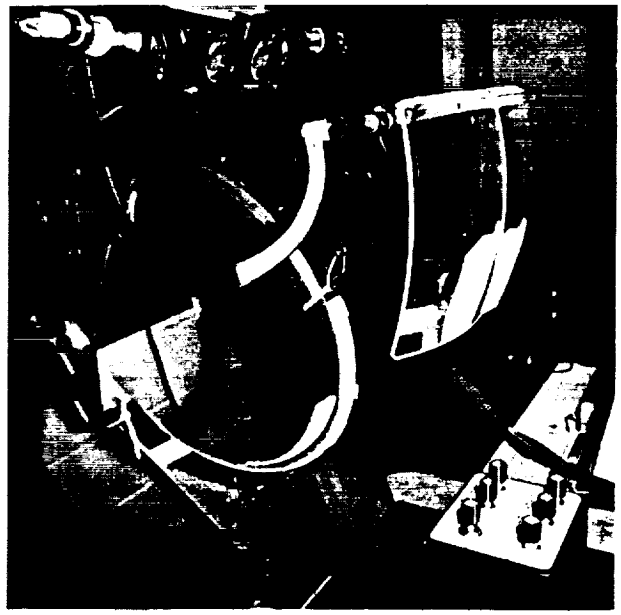




EMU Helmet Mounted Display

OVERVIEW

The Helmet Mounted Display (HMD) is an electro-optical system designed to provide text, graphics, and video of selected data for viewing within the Helmet of an extravehicular crewmember.



S87-41829

OPERATIONAL COMMENTS AND INTERFACE PROVISIONS

HMD imagery is provided on a virtual, see-through display located conveniently above the user's horizontal line of sight. The HMD is attached to the extravehicular mobility unit's (EMU) visor assembly located external to the pressure Helmet.

- The Wright-Patterson HMD demonstrator consists of twin high-resolution (525-line), miniature CRTs (1" diameter x 3" length) that project a binocular image via an optical train/toroidal combiner to the user providing a 24-degree by 45-degree image (1/3 center overlap). The HMD may be interfaced to a speech recognizer to provide a totally "hands-free" environment.

- The Hamilton Standard HMD provides a fully-overlapped, binocular image from backlit, dense (320 x 220 pixel) transmissive LCDs and a projection optics train. The HMD may be interfaced to a speech recognizer to provide a totally "hands-free" environment.

STATUS

The Wright-Patterson HMD demonstrator was delivered to NASA on May 12, 1987, and is currently under evaluation. A Votan 6050 voice recognizer has been interfaced with the HMD and an EVA simulation program has been written for demonstration purposes.

The Hamilton Standard HMD demonstrator is scheduled for delivery to NASA in May 1988.

CONTACTS

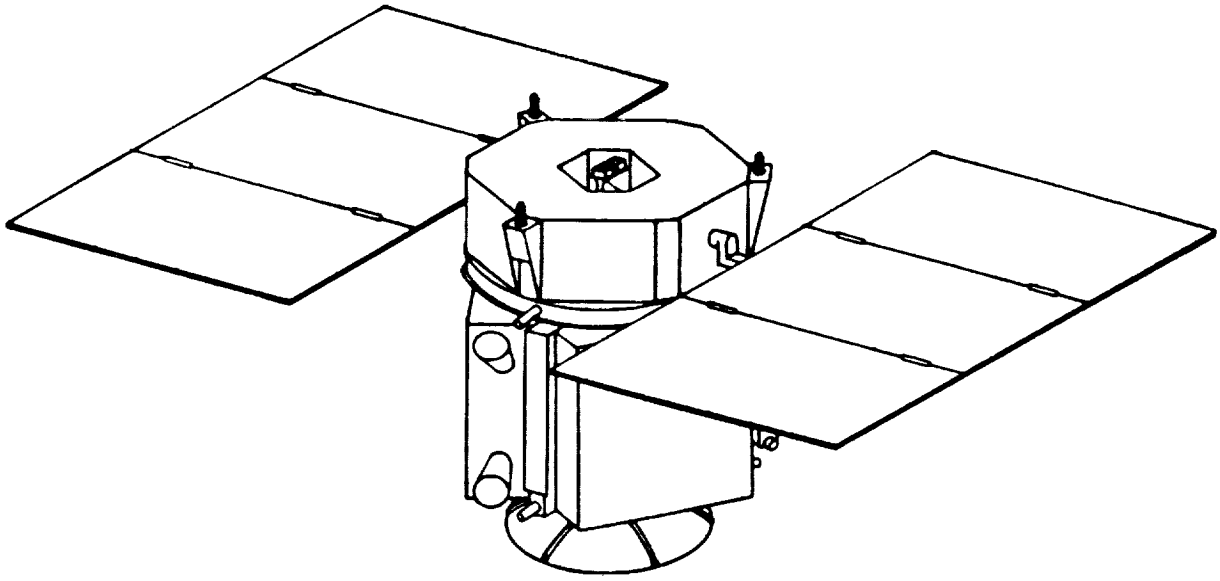
Operational: Jose A. Marmolejo, NASA/JSC/EC3, (713)483-9233
Hai Nguyen, NASA/JSC/EC3, (713)483-9240, Crew and Thermal Systems Division, Crew System Branch

EMU HELMET MOUNTED DISPLAY

Technical Information Wright-Patterson HMD	
Part Number	N/A
Weight	<10 lbs.
Power	3 Watts/CRT, 40-Watt Driver
Status	Demonstrator Hardware
Material	Glass, Polycarbonate, Aluminum
Temperature Range	Room Temperature
Interface Details	110 Vac (60 Hz) RS-170 Video Input

Technical Information Hamilton Standard HMD	
Part Number	N/A
Weight	<10 lbs.
Power	TBD
Material	Glass, Polycarbonate, Aluminum
Temperature Range	Room Temperature
Interface Details	110 Vac (60 Hz) RS-170 Video Input

Explorer Platform



OVERVIEW

The Explorer Platform (EP) is based on the Multi-mission Modular Spacecraft (MMS), which has successfully been implemented on a variety of satellites and proven its effectiveness by being repaired on-orbit. EP can support a variety of remote-sensing, low earth orbiting missions requiring solar, stellar or earth pointing.

OPERATIONAL COMMENTS AND INTERFACE PROVISIONS

The EP presents a standardized telemetry and command interface for integration, test and on-orbit operations with the Tracking and Data Relay Satellite System (TDRSS), using the Deep Space Network (DSN) as backup. EP provides multi-mission versatility by accommodating instrument payload replacement and combining the baseline configuration with mission options and mission-unique equipment to meet specific user requirements.

The design goal of EP is to provide an economical space based platform from which Explorer class instruments can be remotely exchanged. The MMS structure supports the Platform Equipment Deck (PED), which serves as the EP interface to the payload. A payload module is mounted on the PED, and mission-unique equipment can be placed within removable PED modules. When EP is integrated with its payload module, it becomes a mission-unique explorer satellite. Instruments and equipment can be exchanged during Shuttle-based servicing missions.

STATUS

Presently in the technology development stage.

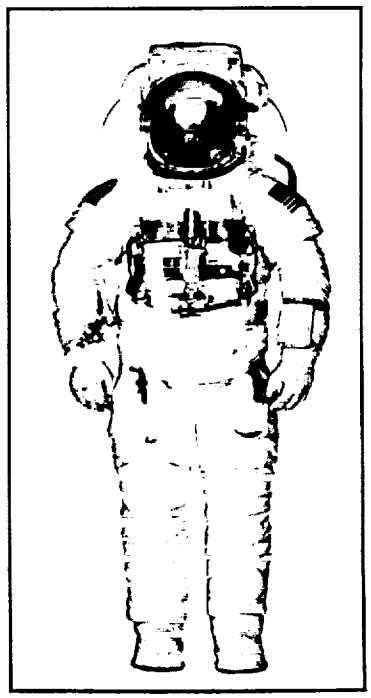
EXPLORER PLATFORM

CONTACTS

Source: Fairchild Space Company
Operational: Frank J. Cepollina, GSFC, (301)286-1359

Technical Information	
Mission Requirements Summary	EP Capabilities
Mission Lifetime	2 yrs. w/o servicing 10 yrs with servicing
Orbit Altitude	300 to 550 km
Orbit Inclination	28.5 degrees
Telemetry Rates	32 kbps 256 kbps direct line 512 kbps direct line
Payload Weight	4000 lbs delta launch 10000 lbs STS launch
Payload Power	300 watts
ACS Type (Attitude)	3 axis stabilized
Maneuvers	2 deg/sec
Pointing Knowledge (3σ)	104.5 sec ACS CO alig only 37.5 sec ACS/INSTR CO alig
Pointing Control (3σ)	105.6 sec ACS CO alig only 40.4 sec ACS/INSTR CO alig

Extravehicular Mobility Unit



S82-40857

OVERVIEW

The Extravehicular Mobility Unit (EMU) is an independent anthropomorphic system that provides crewmembers with environmental protection, life support, mobility, communications, and visibility while performing various EVA's. The EMU has an on-orbit recharge capability and can provide multiple EVA periods during a single flight.

OPERATIONAL COMMENTS AND INTERFACE PROVISIONS

Two EMU's are included in each Orbiter mission without a planned EVA. Three EMU's are flown for a planned EVA mission. Consumables are provided for two two-man, 6-hour EVA's, one of which is for payload use (mission success) and the other reserved for an unscheduled Orbiter safety-critical EVA. For missions with a planned EVA, consumables are provided to support all planned EVA's and an Orbiter contingency EVA. The EMU primary life support system is designed for 7 hours of independent life support, of which only 6 hours are available for nominal EVA's. The EMU also has a backup life support system which can provide 30 minutes of oxygen under reduced suit pressure. Instrumentation and a microprocessor provide the capability to monitor the status of the EMU and expendables and to alert the crewmember of any abnormal system function.

Standard interface attachments are provided for the manned maneuvering unit, the mini work station, tool caddies, EMU television system, EMU lights, and the wrist and waist tethers.

STATUS

Flight qualified. Flown on all STS flights.

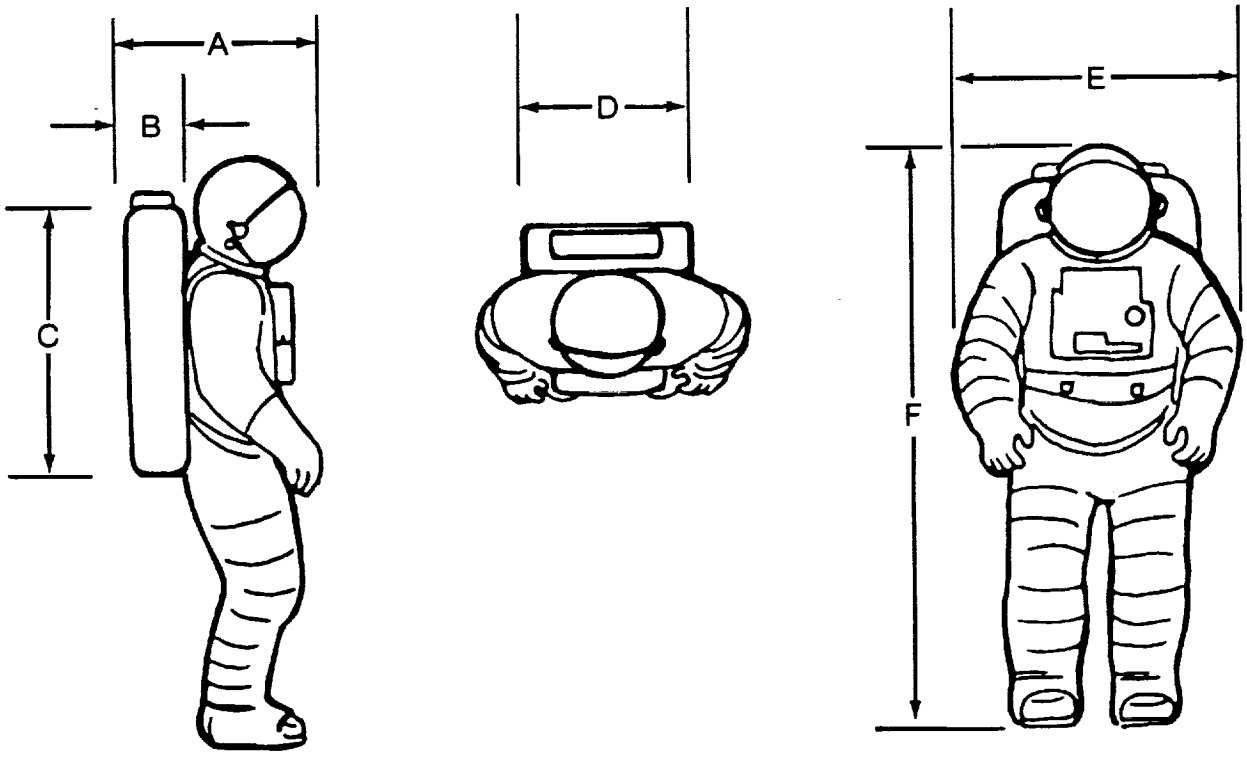
CONTACTS

Source: Hamilton Standard
Operational: C. H. Armstrong, NASA/DG4, (713)483-2588

EXTRAVEHICULAR MOBILITY UNIT

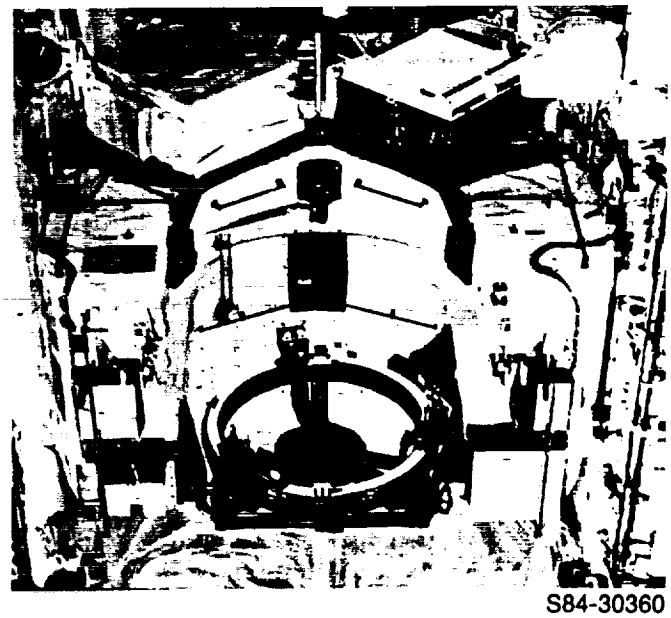
Technical Information	
Part Number	SED 13101492-307
Weight	257 LB (min) 300 lb (max)
Wrist Tether Loop Breaking Force	30 lb

Dimensional Data		
	95% Male	5% Female
A	28.4 in.	26.0 in.
B	7 in.	7 in.
C	32 in.	32 in.
D	23 in.	23 in.
E	29.4 in.	-
F	75.5 in.	67.5 in.



Flight Support System

OVERVIEW


S84-30360

The Flight Support System (FSS) is a reusable equipment system that provides the structural, mechanical, thermal, and electrical interfaces between various spacecraft and the space shuttle for LAUNCH, RETRIEVAL, and ON-ORBIT servicing missions. The FSS was developed as the primary interface between the multimission modular spacecraft and the Shuttle Orbiter for launch, deployment, servicing and landing operations. The FSS configuration consists of three structural cradles, mechanisms for spacecraft retention and positioning, and avionics. The configuration for on-orbit servicing consists of one cradle with the berthing and positioning system, mechanisms, and avionics. The on-orbit servicing configuration in most cass does not include the structural capability to support the spacecraft for launch or landing.

OPERATIONAL COMMENTS AND INTERFACE PROVISIONS

The FSS consists of five major hardware elements:

Cradle A - 16 in. deep cradle with a latch beam which can be used for both servicing and deployment missions.

Cradle B - A 52 in. deep cradle with capability for Shuttle attachment through four Longeron trunnions and one keel trunnion.

Cradle A'- A cradle dimensionally the same as Cradle A with removable cradle extenders.

Berthing and Positioning System (BAPS) -
A movable platform with spacecraft latches and umbilical connectors that provides an on-orbit spacecraft positioning capability for apendage extension or retraction, inspection, pre-deployment testing, deployment, servicing or retrieval berthing.

Lightweight Cradle - A 16 in. deep cradle with two Longeron trunnions and one keel trunnion.

The FSS avionics provide for the electrical operation of the Berthing and Positioning System mechanisms and the electrical support services to the FSS and spacecraft while on the ground and on-orbit. These services include

operating power, externally applied heater power, and serial commands and telemetry relay to the user's Payload Operations Control Center (POCC) via Orbiter avionics. Control and monitor of hardline digital and analog signals by the Orbiter crew are accommodated at the Aft Flight Deck (AFD) using standard Orbiter equipment. These signals can be relayed to the user's POCC. These services on the ground are provided by the Ground Support Equipment (GSE) via the Orbiter's T-0 umbilical. When the FSS/spacecraft is not installed in the Orbiter, the electrical GSE interface is accomplished by directly connecting to the Orbiter Standard Interface Panel (SIP) connectors.

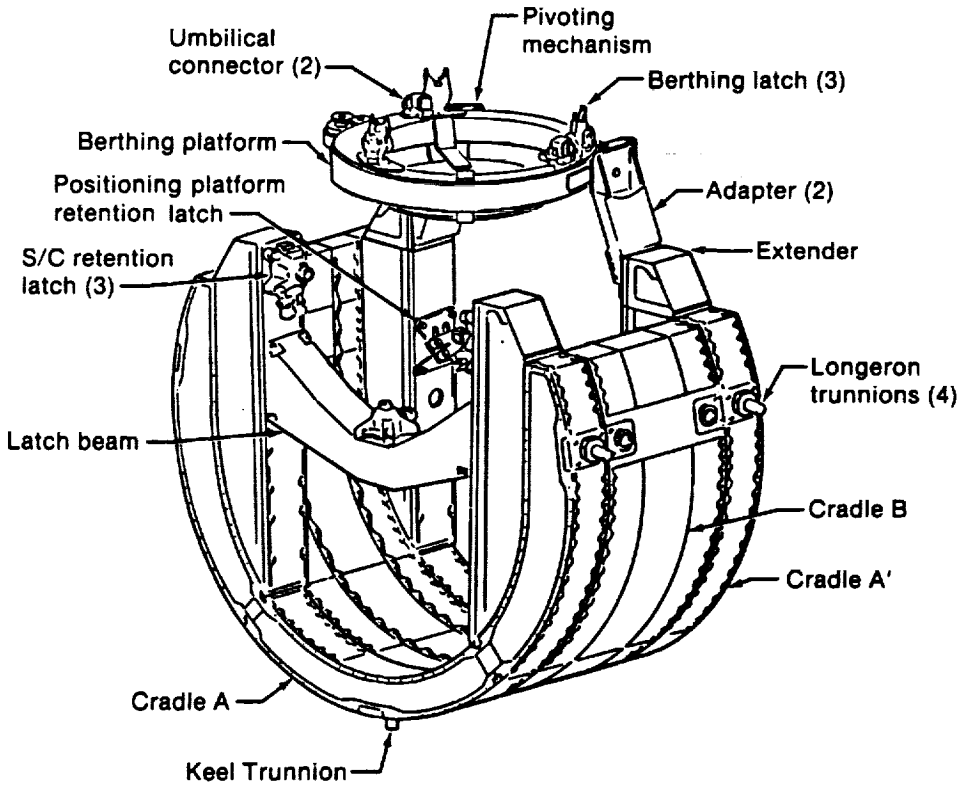
STATUS

Flight Tested. FSS was first used on-orbit during the solar maximum repair mission in 1984.

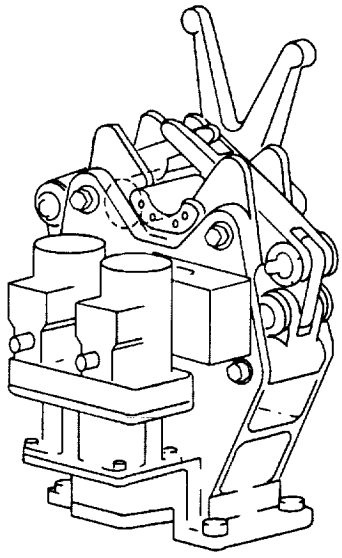
CONTACTS

Source: Fairchild Space Company
Operational: E. Falkenhayn, GSFC/Code 48, Greenbelt, MD 20771 (301)286-4144

Technical Information	
Power	Provides 28 volts D.C. 115 volts 400 Hertz (Hz)



Flight Support System Latch



OVERVIEW

Designed as a part of the Flight Support System (FSS) to provide latching of payload to the FSS. Subsequently, the latch has been incorporated on a number of payloads as a standard berthing/docking latch.

OPERATIONAL COMMENTS AND INTERFACE PROVISIONS

Design for berthing pin diameter of 1.5 in., the latch accommodates misalignments of ±2.0 and ±1.0° half cone angle.

Latch has redundancy from motor up to drive shaft with EVA backup capability.

STATUS

Successfully flown on a number of missions including Solar Max repair.

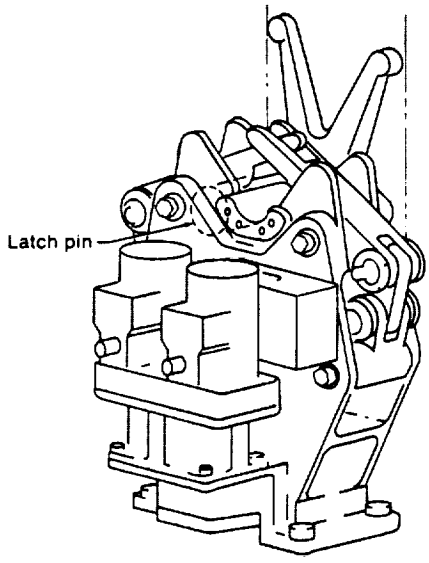
CONTACTS

Source: Rockwell International, 12214 Lakewood Blvd., Downey, CA 90241
Operational: C. W. Anderson, (213)922-5095
R. L. Gasteiger, (213)922-5339

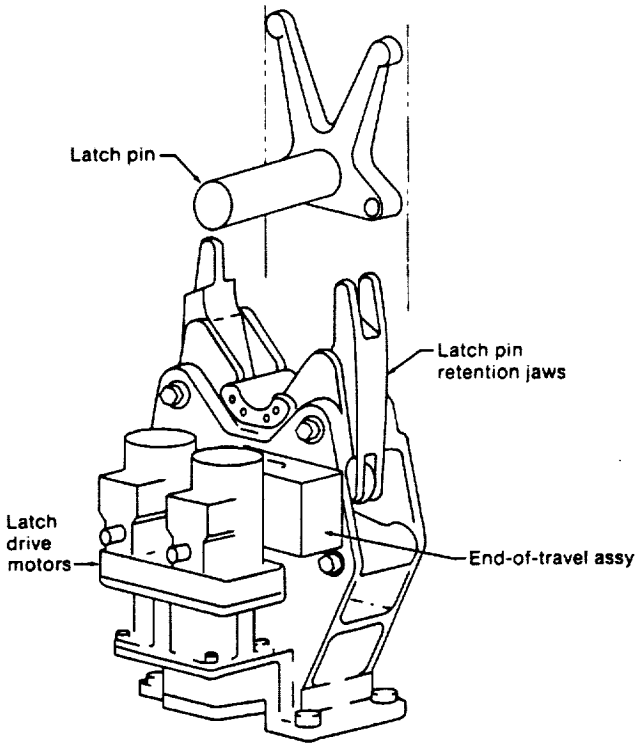
FLIGHT SUPPORT SYSTEM LATCH

Technical Information	
Weight	63 lbs.
Power Req.	Three phase 115 V, 400 Hz.
Temp Range	N/A
Cooling	N/A
Material	
Status	Flight qualified

Interface Details	
Electrical	N/A
Mechanical	
Data Rate	N/A
Documentation	

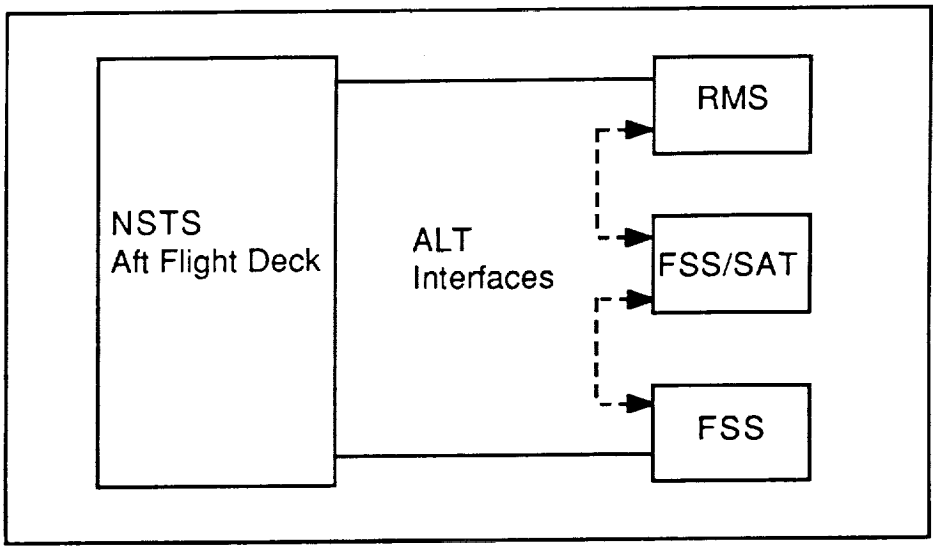


Closed



Open

Flight Support System/Servicing Aid Tool



OVERVIEW

The Flight Support System/Servicing Aid Tool is a remotely-operated bilateral force-reflecting manipulator system. It will enhance the capability of the NSTS Mission Specialists to perform IVA and EVA Free-Flyer Spacecraft servicing in the Space Shuttle Cargo Bay from the Aft Flight Deck.

OPERATIONAL COMMENTS AND INTERFACE PROVISIONS

The system, which mounts to the FSS by a versatile electro-mechanical interface, can be repositioned by use of the remote manipulator system. The FSS/SAT will have provision to pickup and restow tools from a tool storage locker mounted on the FSS. The FSS/SAT will either be stowed in a storage rack or will be secured to the FSS during launch and landing operations. The system is designed to operate from the Space Shuttle onboard utilities.

STATUS

The development of this system, which may be used during a new SMM Servicing Mission and during the Explorer Platform Interchange of Payloads, is in a competitive procurement cycle. Phase I calls for a graphics feasibility simulation, commercial model demonstration, and prototype model design. Phase II calls for production of the system, its flight qualification, 1-g ground demonstration in the GSFC Space Shuttle simulator, and delivery within a two-year period.

CONTACTS

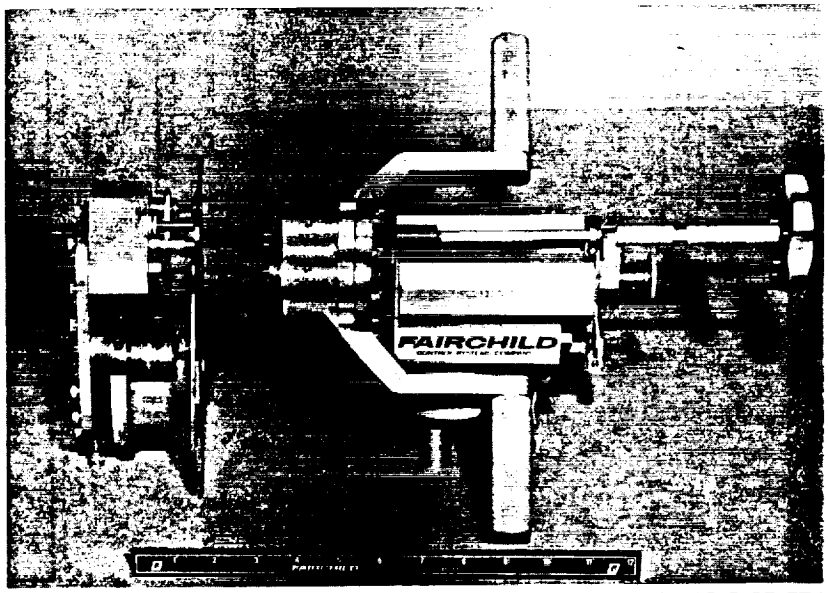
Source: GSFC, Fairchild Space Company, (301)286-2000
Operational: R. E. Davis, NASA/GSFC SSP/CODE 408.0, (301)286-2260

FLIGHT SUPPORT SYSTEM/SERVICING AID TOOL

Technical Information	
Part Number	TBS
Weight	Approx. TBD lb./Manip.
Power	External 28 VDC Shuttle power at TBD watts/manip.
Status	Phase C/D design and hardware development
Materials	Structure - aluminum
Temperature Range	-50 to +100 deg F; degr. -100 to +250 deg. F
Pressure	Min. 10^{-10} Torr
Operations	Intermittant over 4 yrs with minor servicing

Interface Details	
Interface Device	RMS LT-WT FLT releasable electrical grapple fixture and versatile electro-mechanical end-effector
Precapture Misalignment Limits	RMS: 4" pitch/yaw radius. 4" axial, +/-15 Deg all AT and electro-mech EE: TBD
Electrical Connectors	RMS 51-contact modified connector and TBD for FSS/SAT E-M end effector
Cable Type	Interconnections via existing RMS and FSS wiring to AFT flight deck
Type OPNS	Mission specialist contrs RMS and FSS/SAT from Aft Flt deck controllers/panels
Contacts Assignment	RMS per JSC ICD 2-06001 and FSS/SAT TBD

Fluid Connector, EVA



FCSC 109-3-85-574

OVERVIEW

The EVA Fluid Connector is a coupling device designed for transferring fluids and low pressure gases. The Fluid Connector has three manual valves with positive pressure indicators in each coupling and a pressure transducer to check valve integrity. Triply redundant interface seals between coupling halves have pressure ports to check seal integrity. Interlocks prevent valve opening while a coupling is disengaged and prevent coupling disengagement with a valve open.

OPERATIONAL COMMENTS AND INTERFACE PROVISIONS

The Fluid Connector is connected by first aligning the tanker coupling (male) and the spacecraft coupling (female) halves and then engaging. By means of the handle grips, the tank coupling is rotated clockwise approximately 40° until the handles are horizontal. The locking pin is then rotated clockwise. The seal integrity is checked, and the safety lever is pulled forward and down exposing the flow control valves. The valves are opened in the following order: T-3, T-2, S-3, S-2, allowing fluid transfer. The operations, from rotating the locking pin through opening the valves, are clearly numbered 1 through 7 on the face of the tool. These steps are reversed (7 to 1) to close the valve and remove the tool. Designed to be used to refuel the Gamma Ray Observatory (GRO).

STATUS

The EVA Fluid Connector is undergoing flight qualification testing.

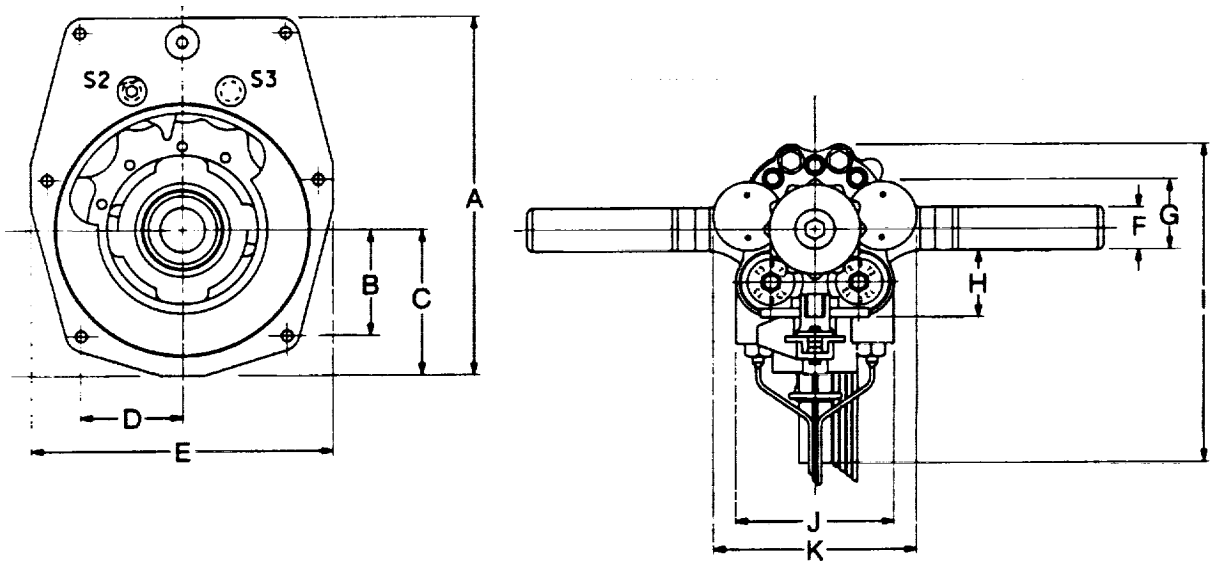
CONTACTS

Source: Fairchild Control System Company
Operational: R. C. Trevino, NASA/DL4, (713)483-2597

FLUID CONNECTOR, EVA

Technical Information	
Part Number	Not available
Weight	13.0 lb
Material	Stainless steel
Operating Pressure	500 psig nominal, 600 psig maximum
Operating Temperature	40° F minimum, 70° F nominal, 120° F maximum
Flow rate	10 gpm nominal, 20 gpm maximum

Dimensional Data	
A	7.82 in.
B	2.330 in.
C	3.16 in.
D	2.34 in.
E	6.82 in.
F	1 in.
G	1.6 in.
H	1.5 in.
I	7.5 in.
J	3.7 in.
K	4.8 in.



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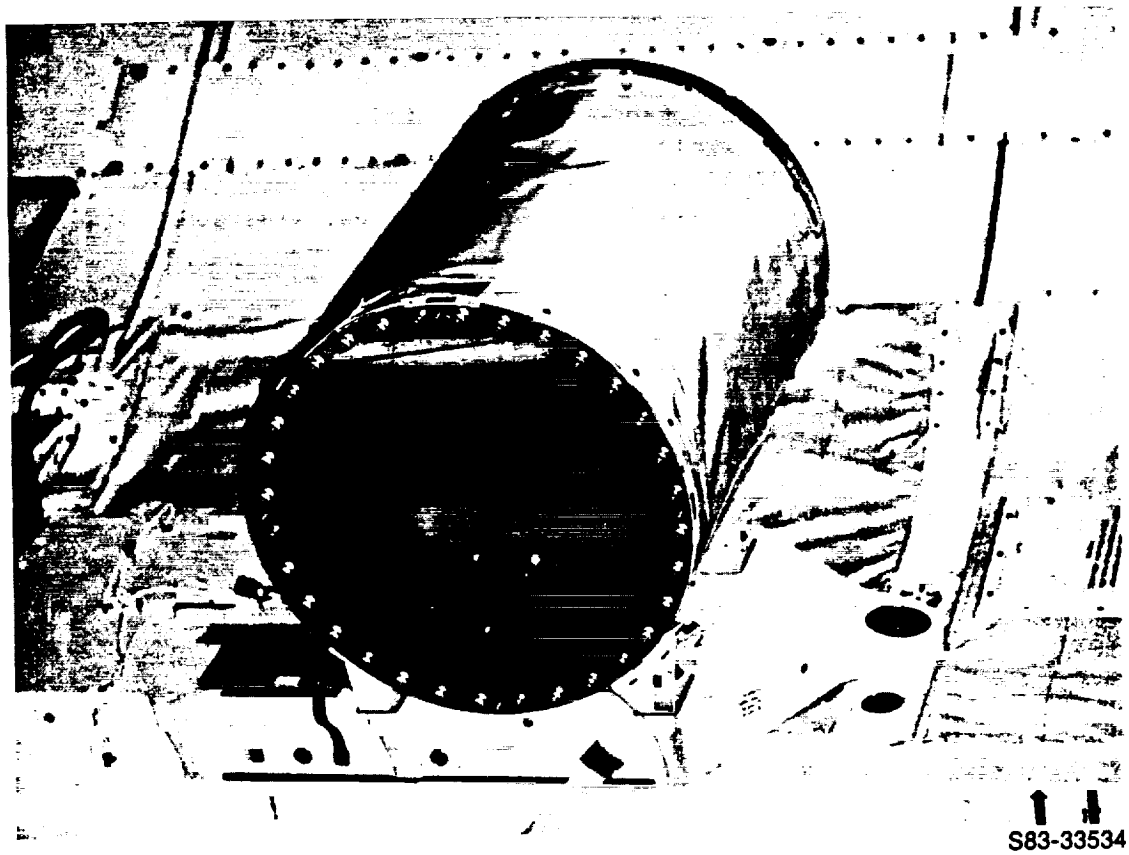
Getaway Special Beam



OVERVIEW

The Getaway Special Beam (GAS) Beam is a structural frame to which small payloads can be attached.

OPERATIONAL COMMENTS AND INTERFACE PROVISIONS

The GAS Beam, which connects to the longerons on either side of the Cargo Bay, can be attached at any of 30 sites, and a total of 30 GAS Beams may be carried on a Shuttle mission. The GAS Beam does not contain any interface provisions for electrical power, control, or monitoring.

STATUS

Flight qualified and has flown on several Shuttle missions.

CONTACTS

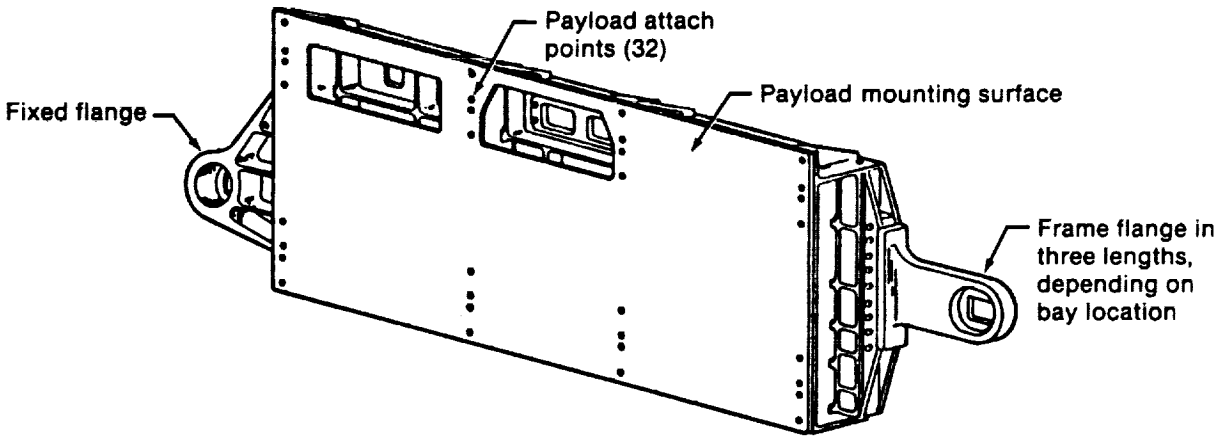
Source: Rockwell International
Operational: Bill Ponce, RI, (213)922-4036

GETAWAY SPECIAL BEAM

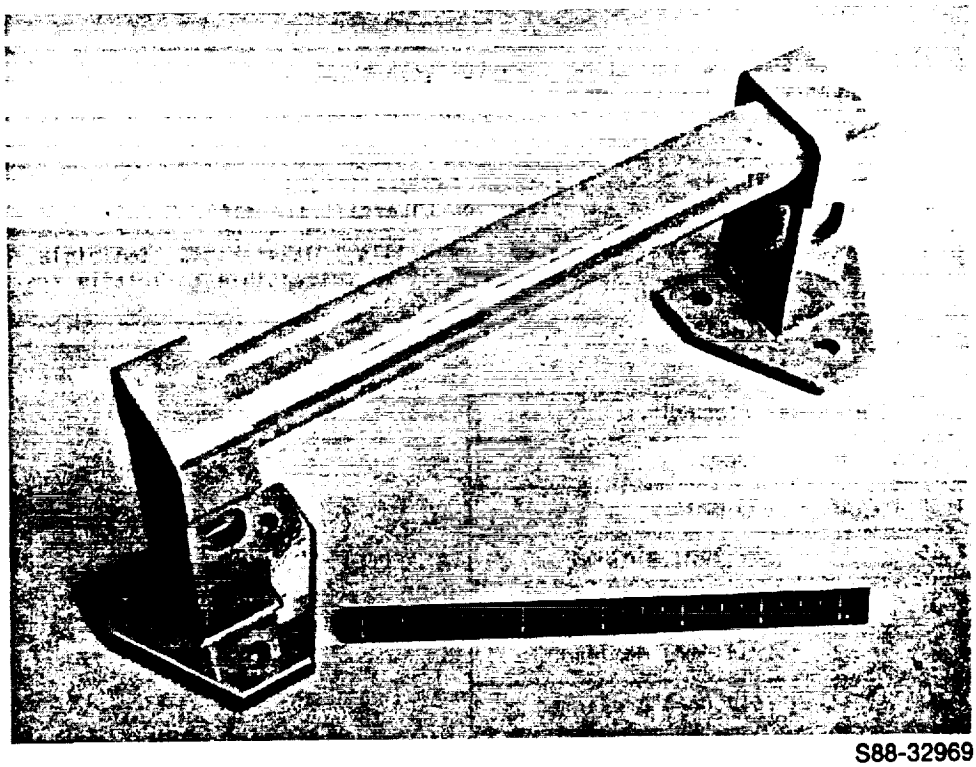
REFERENCES

Fitting Assembly - Adapter Beam Bridge Getaway Special.
Drawing no. V724-340001, Rockwell.
Space Shuttle Interface Control Document. ICD-A-14021, November 1979.
STS and Getaway Special (GAS) Payload Integration Plan, Rev. B, JSC-14021, March 1983.

Technical Information	
Beam Length	52.3 in.
Beam Width	6.0 in.
Beam Height	22.4 in.
Maximum weight of payload at a 6.0--in. moment arm: 300 lb	



Handrail, EVA



S88-32969

OVERVIEW

The EVA HANDRAIL provides a mobility aide for EVA crews during planned work in the payload area. The handrail consists of standoffs with integral tether attachment points and a standard cross section rail for gloved handgrip.

OPERATIONAL COMMENTS AND INTERFACE PROVISIONS

EVA Handrails are provided on the bulkhead at each end of the payload bay and at strategic points along the length of the payload compartment. The handrail is designed such that standoffs and the rail can be replaced as separate components.

STATUS

Design is complete and the handrail system is being used on the Hubble Space Telescope EVA tool box. Numerous designs for EVA handrails exist and are in varying stages of development.

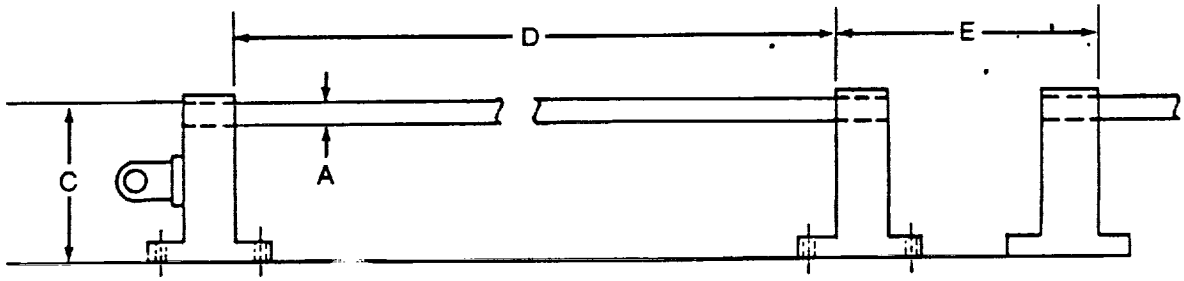
CONTACTS

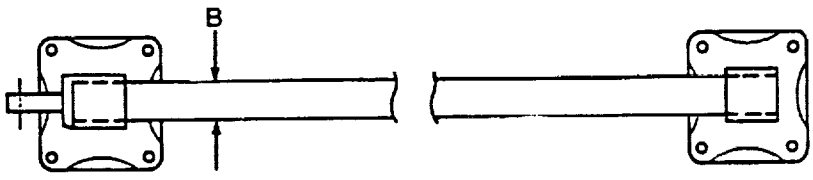
Source: ILS Space Systems Divison
Operational: R. Fullerton, NASA/JSC/DF 421, (713)483-2789

HANDRAIL, EVA

Technical Information	
Material	6061 - T6 aluminum tubing (minimum griplength of handholds/handrails for EVA)
Length	5.81 in. (14.75 cm.)
Forces	187 lb (841.5N) in any direction (Handrail tube) 547 lb (2450.56N) in any direction (Handrail standoff)
Handholds and handrails shall be fabricated from metals. Other rigid, semirigid, or nonmetallic materials also may be used but must not be susceptible to brittle fracture.	

DIMENSIONS (INCHES)		
A	0.75 ± 0.06	(19mm)
B	1.38 ± 0.06	(33 mm)
C	2.25	(57.2mm) minimum
D	5.81	(147.5mm) minimum
E	36.0	(914.4mm) maximum
	24.0	(610.0mm) preferred





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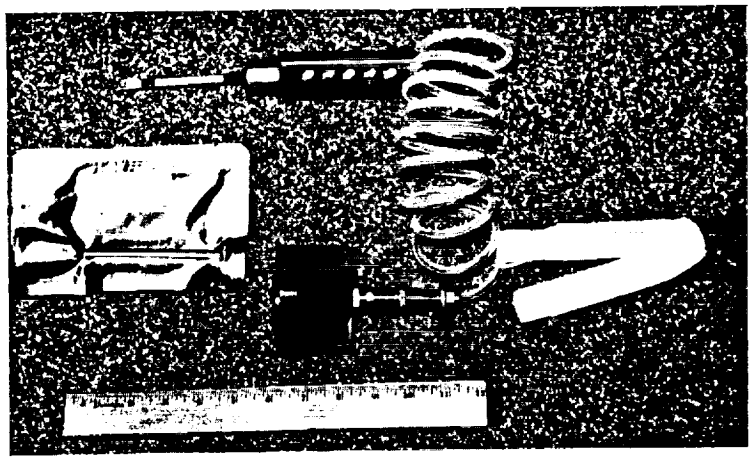
Hydrazine Detector



S84-41548

OVERVIEW

The hydrazine detector is intended to be only a qualitative sampler of hydrazine contamination. The detector kit consists of two parts, the air sampler and the detector tube. The air sampler consists of an airlock depress valve cap, a tube holder, and coiled Teflon tubing. The detector tubes are covered with Teflon shrink tubing and are packaged in standard foil-mylar vacuum packaging.

Detection is based upon the chemical reaction of hydrazine with a crystaline-line mixture of yellow acetic acid and bromophenol blue. Reaction occurs as the airlock atmosphere is drawn through the reactants. The crystals change color from yellow to blue upon contact with hydrazine.

OPERATIONAL COMMENTS AND INTERFACE PROVISIONS

The system is stowed in the airlock's EVA bag prior to depress and is assembled by the EVA crew for use after airlock repress to cabin pressure. Operation and contamination detection involves a 20- to 30-second depress of the airlock with visual observation of a color change in the detector. If hydrazine is detected, the EVA crew will return to vacuum to sublimate any combination. This system is known as the Draeger tube in crew procedures.

STATUS

Flight qualified. Flown on specific STS missions.

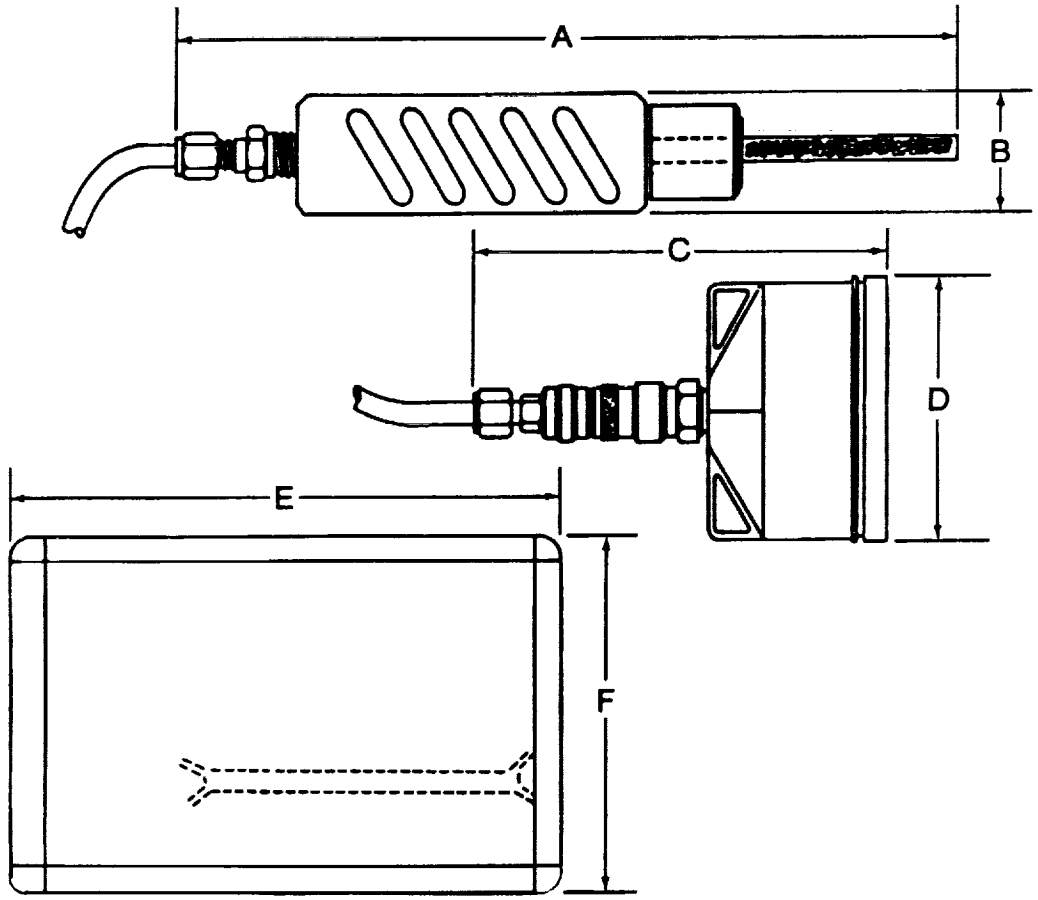
CONTACTS

Source: R. K. Fullerton, NASA/DG4, (713)483-2589
Operational: R. J. Marak, NASA/EC5, (713)483-9144

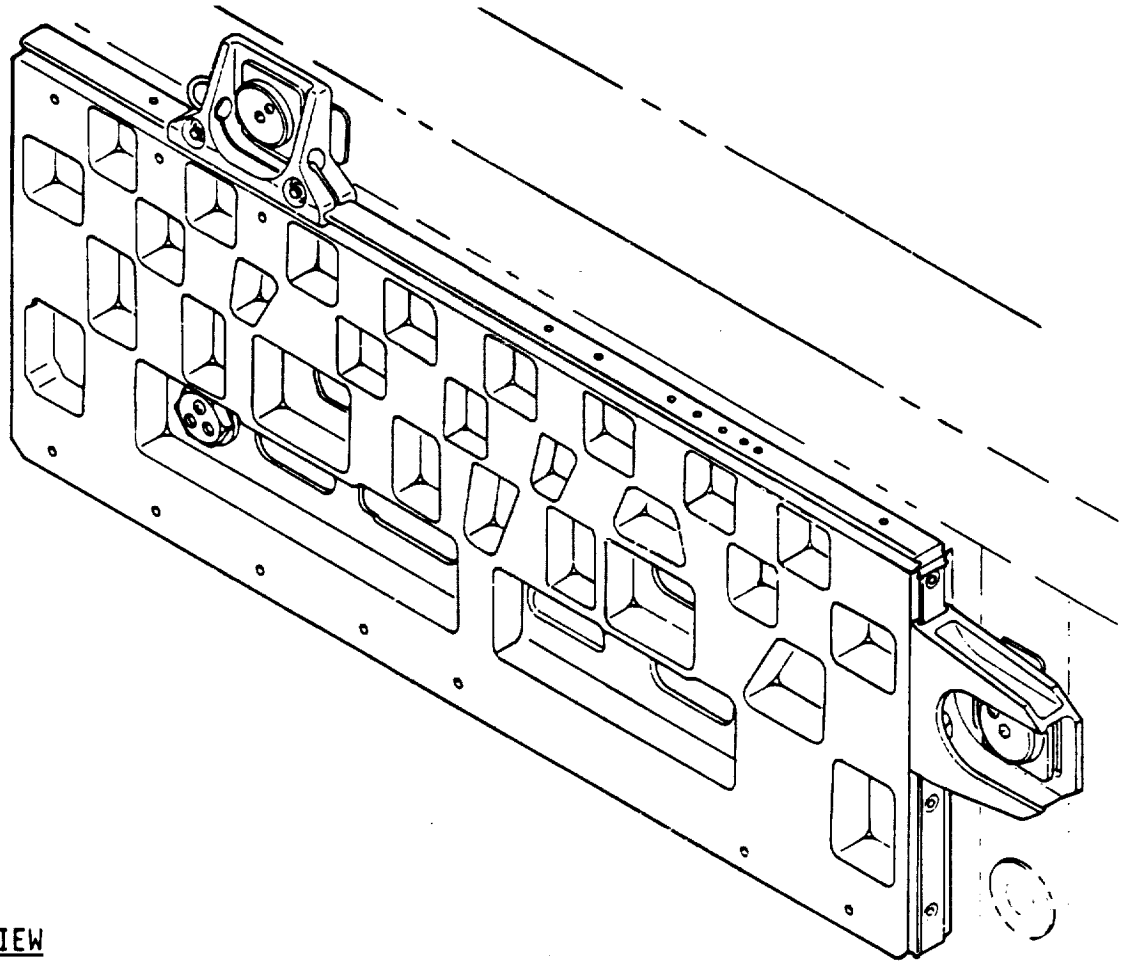
HYDRAZINE DETECTOR

Technical Information	
Part Numbers	SED 39116311-301 (air sampler) SED 39117159-301 (Draeger tube)
Weight	1.3 lb
Material	Package - foil-mylar Tubing - Teflon Tube holder - anodized aluminum Valve cap - anodized aluminum Draeger tube - glass covered by Teflon shrink tubing
Force/Torque	Attach cap to depress valve - hand-tight
Design Temperature Range	50° to 122° F
Accuracy	Qualitative only

Dimensional Data	
A	9.75 in.
B	1.5 in.
C	5.25 in.
D	3.125 in.
E	6.875 in.
F	4.25 in.



Increased Capability Adaptive Payload Carrier



OVERVIEW

The Increased Capability Adaptive Payload Carrier (ICAPC) is design-based upon APC. Provides increased weight carrying capability for payload bay sidewall mounted payloads.

OPERATIONAL COMMENTS AND INTERFACE PROVISIONS

Mounts in 23 positions on each side of the payload bay. Unique port and starboard ICAPC's, which excludes bay 1 and aft section of bay 2.

500 lb. load carrying capability.

STATUS

Four (4) Port and four (4) Starboard units fabricated.

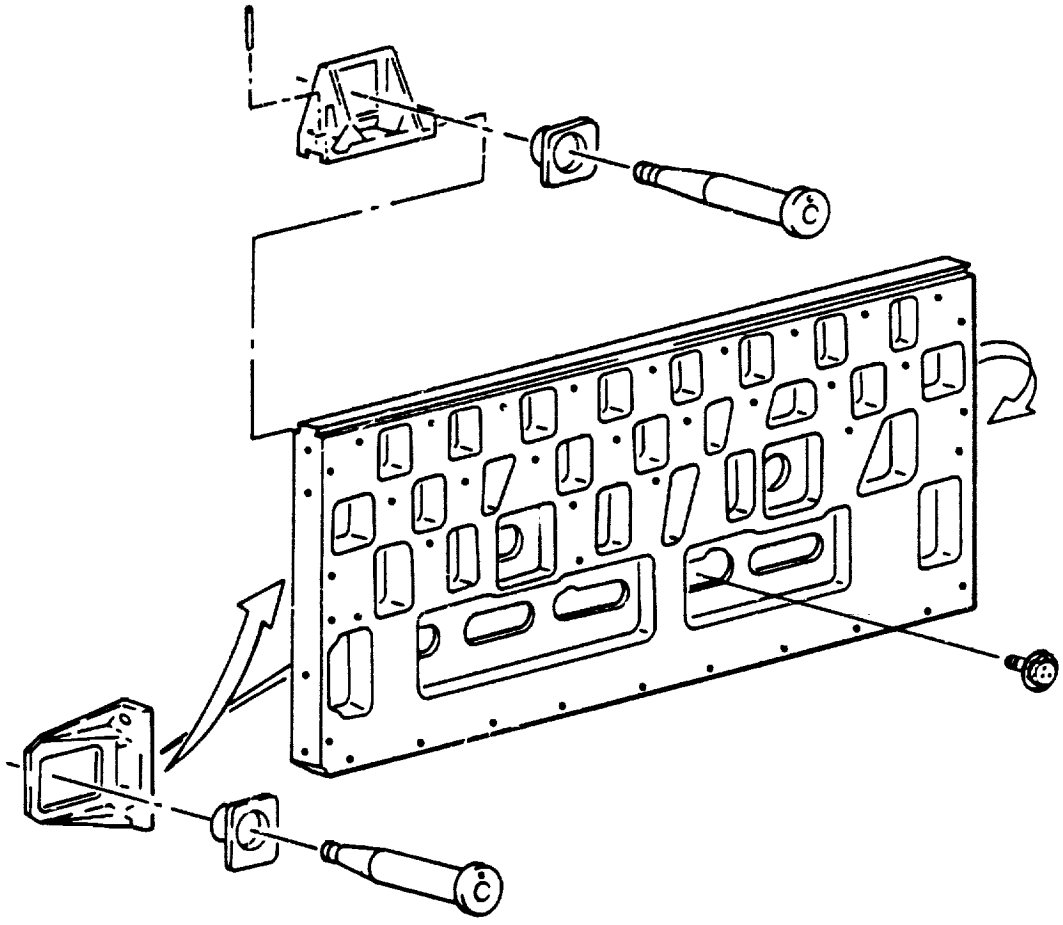
CONTACTS

Source: Rockwell International, 12214 Lakewood Blvd., Downey, CA 90241
Operational: C. W. Anderson, (213)922-5095
R. L. Gasteiger, (213)922-5339

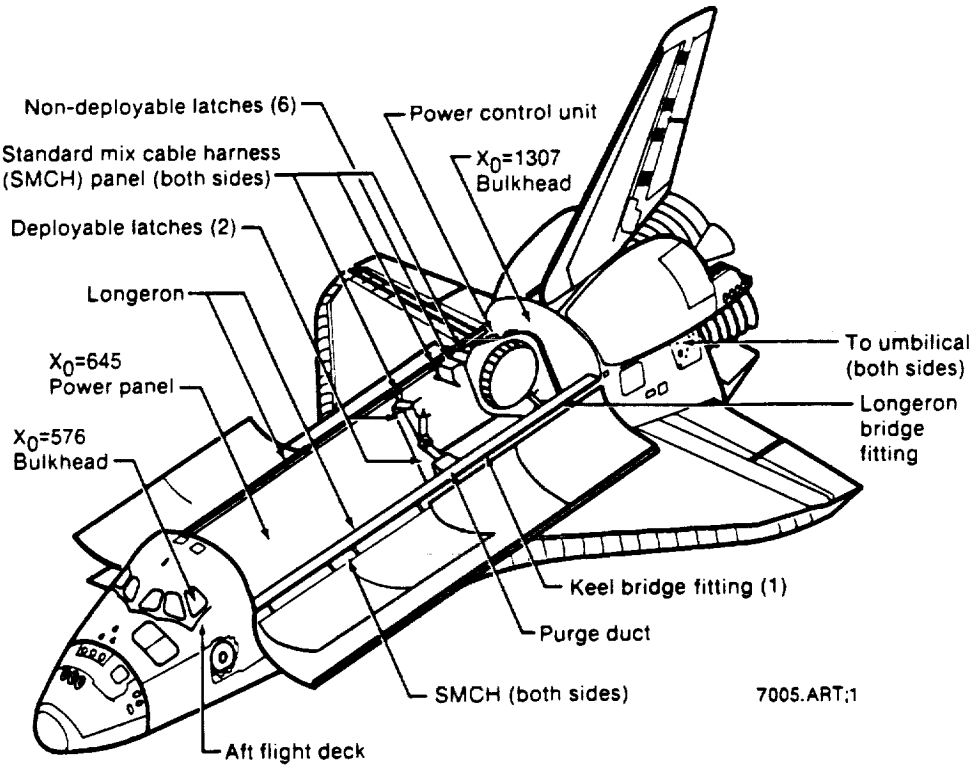
INCREASED CAPABILITY ADAPTIVE PAYLOAD CARRIER

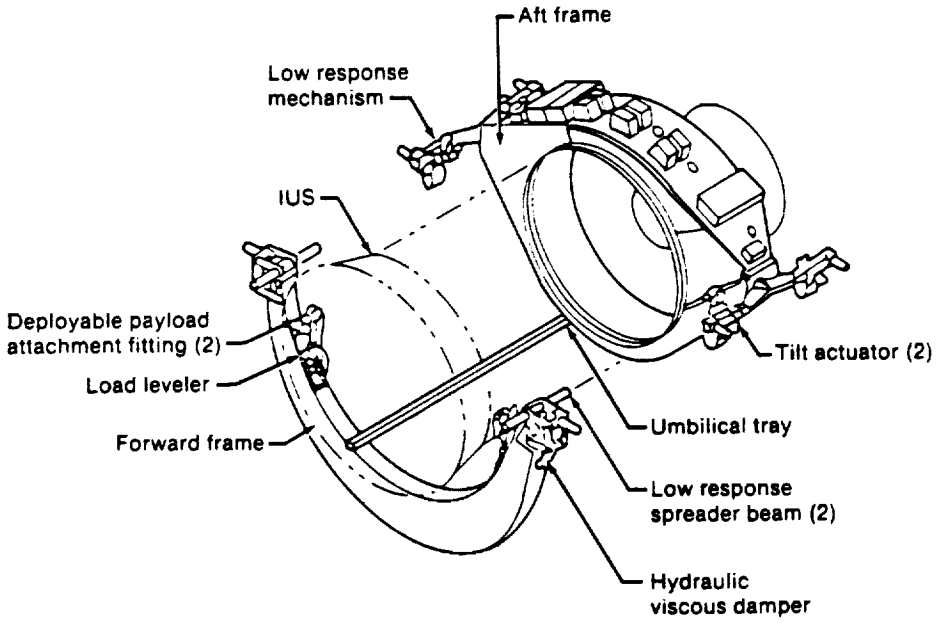
Technical Information	
Weight	53 lbs.
Power Req	N/A
Temp Range	N/A
Cooling	N/A
Material	Aluminum
Status	Flight qualified.

Interface Details	
Electrical	N/A
Mechanical	Attaches to orbiter main frame, stub frame, and longeron sill.
Data Rate	N/A
Documentation	Design Requirements Document STS 85-0162



Inertial Upper Stage Airborne Support Equipment





OVERVIEW

The Inertial Upper Stage Airborne Support Equipment (IUS/ASE) is an adjustable platform which provides the proper orientation for IUS stowing and deployment.

INERTIAL UPPER STAGE AIRBORNE SUPPORT EQUIPMENT

OPERATIONAL COMMENTS AND INTERFACE PROVISIONS

The IUS/ASE consists of two structural frames rigidly mounted in the Orbiter Cargo Bay. The aft frame is a structural ring which supports the aft end of the IUS and pivots to erect the IUS and spacecraft out of the Cargo Bay for deployment. The aft frame is attached to the aft ring of the IUS first-stage solid-rocket motor with a spring-loaded separation system. The forward frame provides rigid support for the forward ring of the IUS. The IUS separates from the forward frame during the aft frame pivot prior to deployment. The ASE power subsystem, which is self-contained, provides the distribution and switching of power between the IUS/spacecraft combination and the Orbiter. The ASE electrical systems are monitored from the Aft Flight Deck of the Orbiter by means of a display and control panel.

STATUS

The IUS/ASE is flight qualified. Flown on specific STS flights.

CONTACTS

Source: Boeing
Operational: William J. Hungerford, NASA/JSC/IB, (713)282-1960

REFERENCES

Inertial Upper Stage Orbital Operation Handbook. Boeing, D290-10554-1.
Shuttle Orbiter/Inertial Upper Stage Cargo Element Interfaces. ICD-D-E0001.

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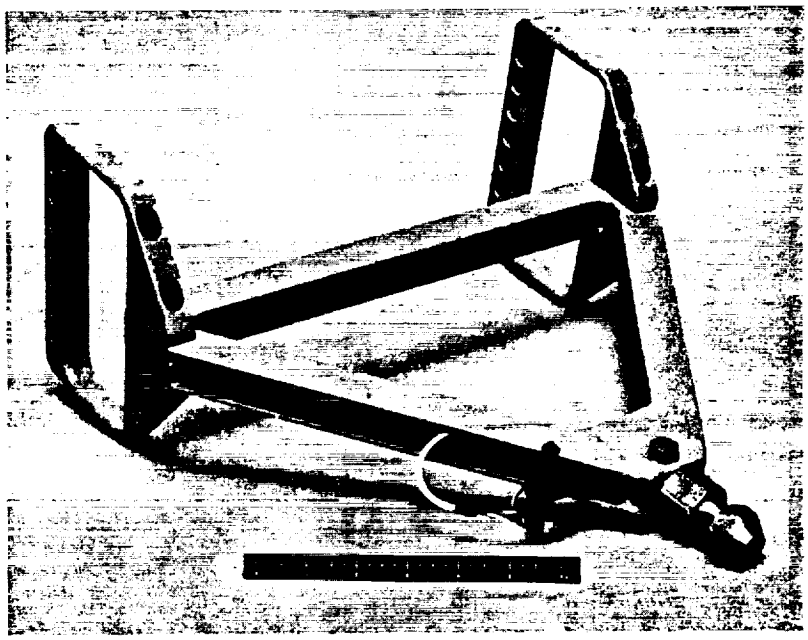
Jettison Handle



S88-32952

OVERVIEW

The jettison handle is a contingency tool designed for the space telescope. If the space telescope must be returned to the payload bay, all appendages must be folded back into their original positions. If, for some reason, an appendage is unable to be returned to its original position, either automatically or manually, the EVA crewmember must then jettison the appendage using the jettison handle. The solar arrays and aperture door have a mounted socket which mates with the jettison handle.

OPERATIONAL COMMENTS AND INTERFACE PROVISIONS

The jettison handle connects into a socket located on the failed appendage near the center of gravity of the appendage and provides a means of holding the appendage structure for easy movement away from the space telescope.

STATUS

Flight hardware, flight ready and will be manifested on STS-31.

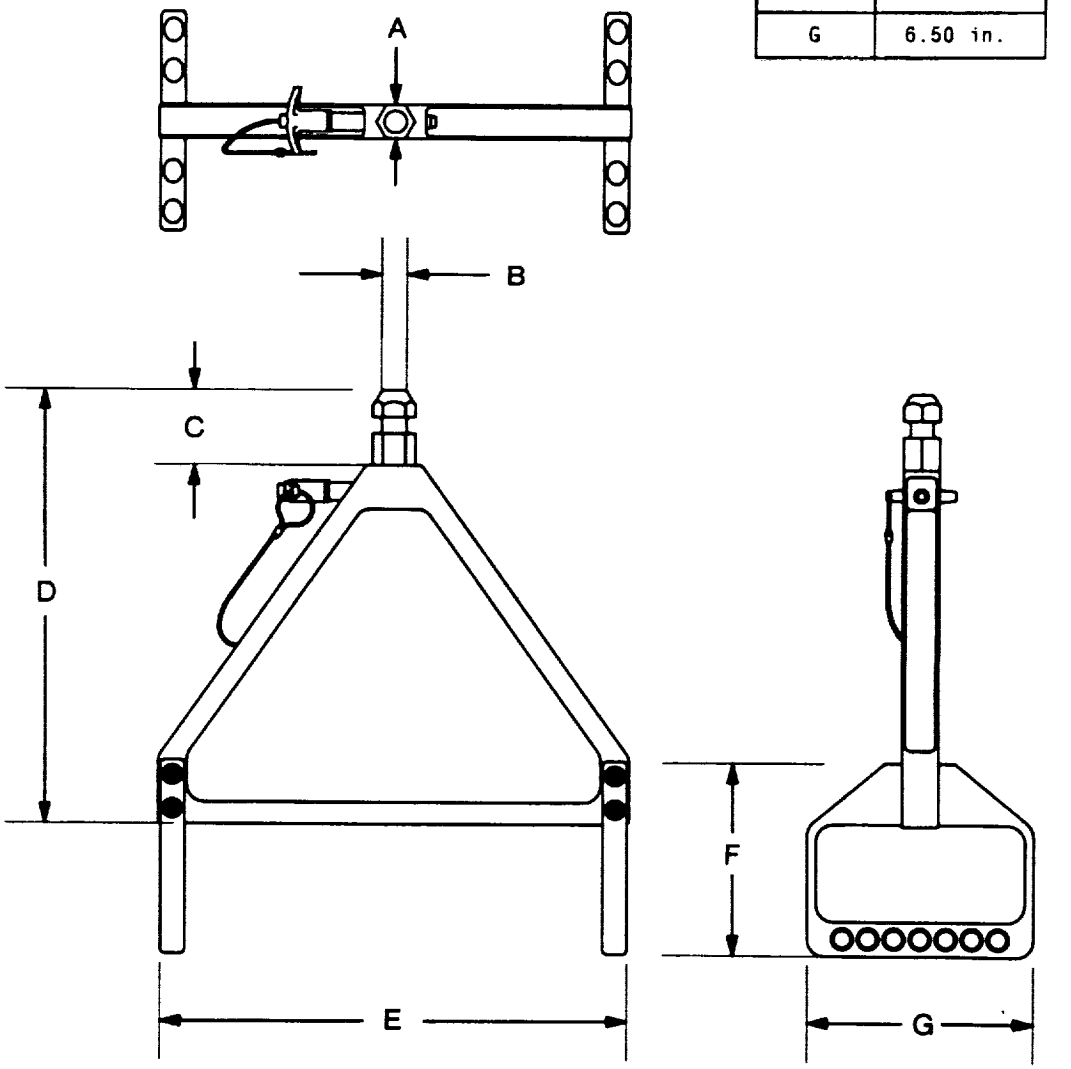
CONTACTS

Source: LMSC, HST Contracts Office, (408)742-5505
Operational: R. C. Trevino, NASA/JSC/DF 42, (713)483-2597

JETTISON HANDLE

Technical Information	
Part Number	4175850
Weight	2.95 lb
Material	Aluminum alloy

Dimensional Data	
A	0.980 in.
B	1.50 in.
C	2.250 in.
D	12.72 in.
E	13.54 in.
F	5.65 in.
G	6.50 in.



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Jumper Cable

S84-28131

OVERVIEW

The jumper cable is an 11-foot electrical cable with a female electrical connector on one end and a male electrical connector on the other. Each end has two captive bolts used in mating the jumper cable to the desired interface. A tether ring is provided on both sides of the male connector.

OPERATIONAL COMMENTS AND INTERFACE PROVISIONS

The jumper cable was designed to provide an electrical interface during the servicing of the Solar Maximum satellite (Solar Max). The jumper cable is manually mated to the Solar Max connector. The two bolts on the jumper cable connector are tightened by rotating approximately seven full turns clockwise with a tool having a 7/16-inch hex socket. This procedure is then repeated with the other end of the jumper cable at the Flight Support System (FSS) umbilical connector actuator position.

STATUS

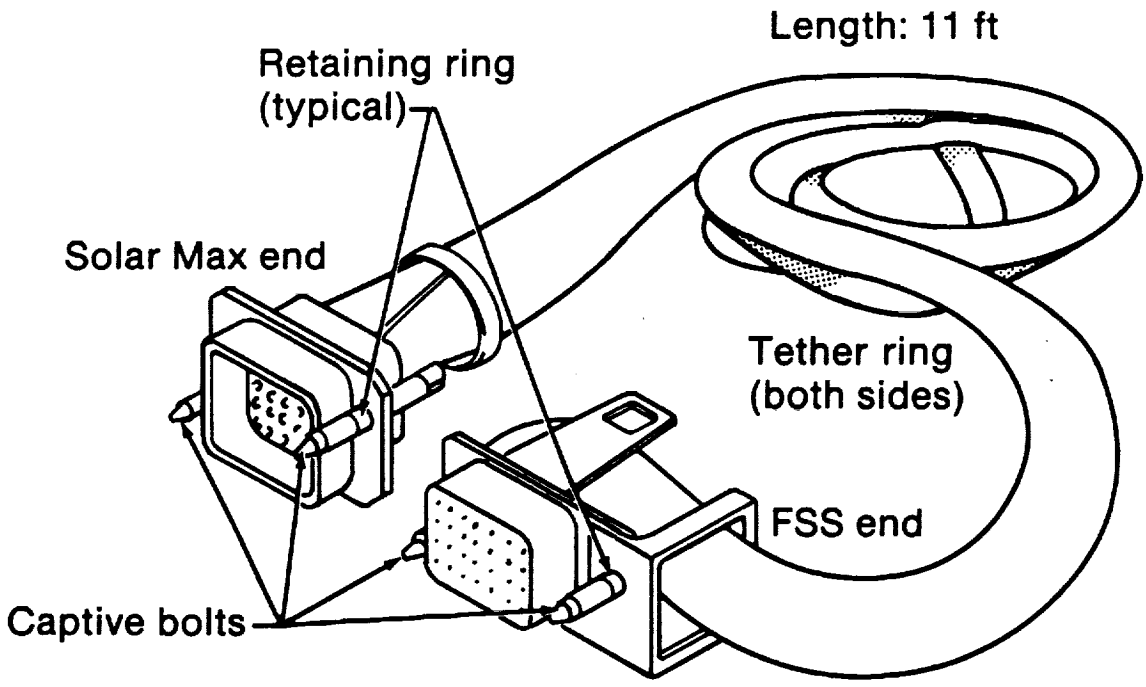
Flight qualified. Flown on STS-41B.

CONTACTS

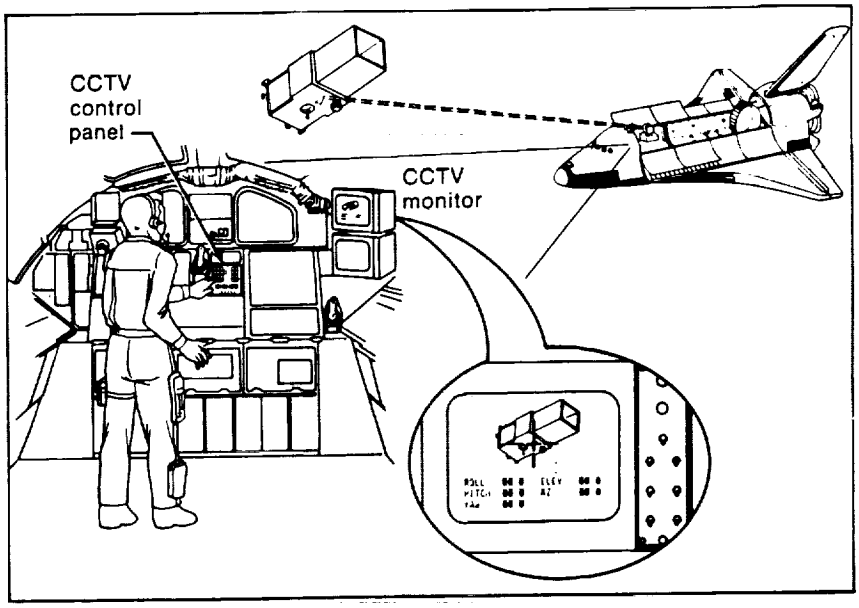
Source: K. Rosette, NASA/GSFC, (301)344-7201
Operational: K. A. Havens, NASA/JSC/DF, (713)483-2569

JUMPER CABLE

Technical Information	
Part Number	9390000608
Weight	17 lb
Material	Cable - black Teflon webbing Connector housing - irradiated aluminum
Temperature Range	-94° to +158°F



Laser Docking System



OVERVIEW

The Laser Docking System (LDS) consists of passive docking aids (reflectors) placed on the target vehicle in a known location and orientation. These reflectors are acquired and tracked by means of a modulated laser beam located on the interceptor vehicle. The LDS enables the interceptor vehicle to analyze the return (reflected) signal in order to determine both relative position and relative attitude of the target vehicle during stationkeeping and docking.

OPERATIONAL COMMENTS AND INTERFACE PROVISIONS

Space operations require soft docking and/or maintenance of a fixed relative attitude while stationkeeping. In either case, a versatile, lightweight stationkeeping and docking system is needed to augment or replace visual tracking of the target vehicle. Massive or flexible spacecraft requires greater sensor system accuracy to minimize contact forces and moments, docking mechanism mass and complexity, vehicle dispersions, and fuel expenditures. In addition, a docking/stationkeeping system permits long-term stationkeeping to be performed in an automatic mode to relieve the crew of the workload and tedium of monitoring relative positions and applying corrective maneuvers. Eventually, this system capability will enable automatic rendezvous and docking.

Laser ranging experiments have been accomplished at NASA, and from these experiments have evolved laser docking concepts. The concepts include angle and attitude measurements which are capable of providing all of the information needed for automatic docking control by the interceptor vehicle. Several designs are being compared. Plans include the development and testing of, first, a breadboard model; then an engineering model; and finally, qualification and flight systems.

LASER DOCKING SYSTEM

Well in advance of operational stationkeeping and docking, a standard configuration for payload-mounted passive tracking aids needs to be established. This will enable payloads which are launched in the near future to be configured before launch for future on-orbit servicing. The LDS will function effectively within a range of approximately 1 km for close-range stationkeeping and for docking and tracking.

STATUS

The LDS concept described above is currently being evaluated at the Johnson Space Center.

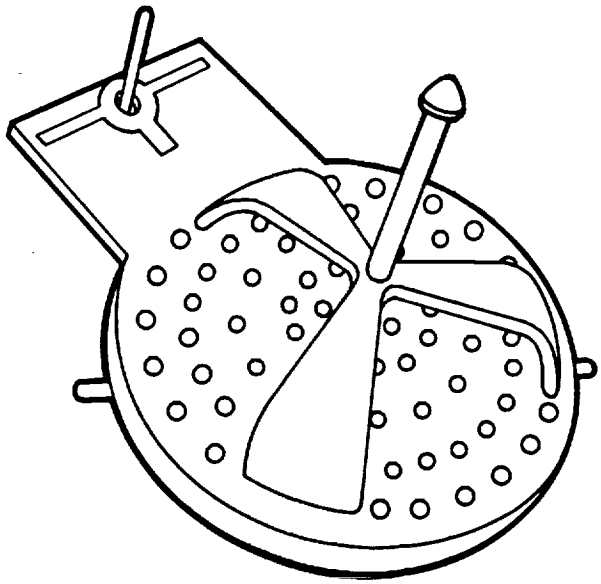
CONTACTS

Source: NASA/JSC
Operational: Harry Erwin, NASA/JSC/IC, (713)282-1822

REFERENCES

Satellite Services Workshop, Vol. 1, JSC-18201. NASA/JSC, June 1982.

Light-Weight Grapple Fixture



OVERVIEW

The Light-Weight Grapple Fixture (LWGF) provides a low weight, reduced abutment plate diameter alternative to the Standard Grapple Fixture.

OPERATIONAL COMMENTS AND INTERFACE PROVISIONS

The LWGF serves the same functional requirements as the Flight Releasable Grapple Fixture by providing the mechanical interface between the Shuttle Remote Manipulator System End Effector and a payload. The LWGF offers the added advantage of low weight providing a reduced abutment plate diameter and satisfies all other major Grapple Fixtures characteristics such as load carring capability.

The LWGF is a development from the original Grapple Fixture design and can at the completion of formal qualification testing replace the original heavier design. The design includes EVA release provisions and may be adapted to provide electrical interface with the End Effector.

STATUS

Hardware built and tested to qualification levels.

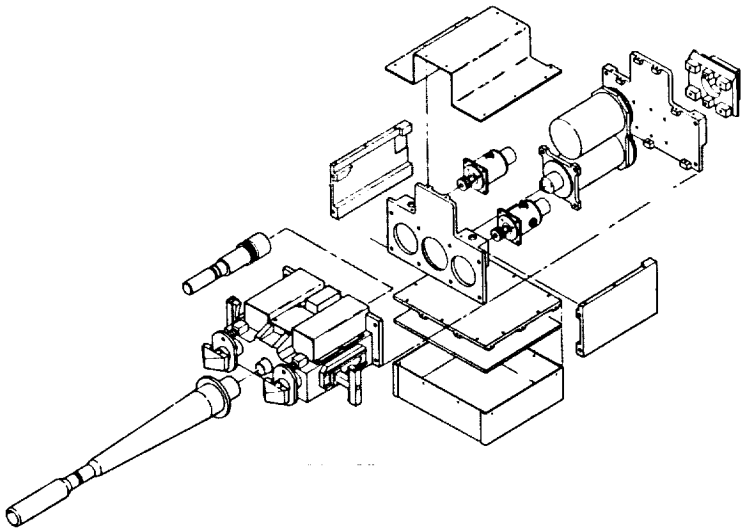
CONTACTS

Source: Spar Aerospace Limited, 1700 Ormont Dr. Weston, Ontario Canada MGL-2W7
Operational: B. Hill, Spar, (416)745-9680

LIGHT-WEIGHT GRAPPLE FIXTURE

Technical Information	
Weight	12 lbs. maximum
Abutment Plate	14.25 in. diameter
EVA releasable	
Electrical connector option	

Light-Weight Module Servicing Tool



OVERVIEW

The Light-Weight Module Service Tool (LW/MST) is a device to permit remote on-orbit exchange of Orbital Replacement Units (ORUs) when coupled to an automated servicer system. It is being redesigned for use with the Orbit Maneuvering Vehicle, Flight Support System/Servicing Aid Tool, Remote Manipulator System, other manipulator and robotic servicers. This tool will permit on-orbit exchange of spacecraft modules, payloads, and instrument orbital replacement units for the Explorer Platform, Orbit Maneuvering Vehicle, Solar Maximum Mission, Upper Atmosphere Research Satellite, and other missions. Remote computer or manipulator control is retained to permit the servicing operations to be performed from the Shuttle aft flight deck.

OPERATIONAL COMMENTS AND INTERFACE PROVISIONS

The LW/MST receives external 28 VDC to power its latch and bolt motors with torque selectable up to 220 ft-lbs. Remote control can be performed by either manual or automated modes. The current end-effector accommodates the integrated orbital servicer system, but special adaptations can be made for other requirements. The electrical umbilical accommodates command, telemetry, bolt and latch motor functions.

STATUS

Electrical and mechanical design modifications for the 1-g engineering model light-weight module service tool are underway to permit on-orbit operations. A companion holster, for mounting of the tool on the MMS Flight Support System or other structural cradles is also undergoing development.

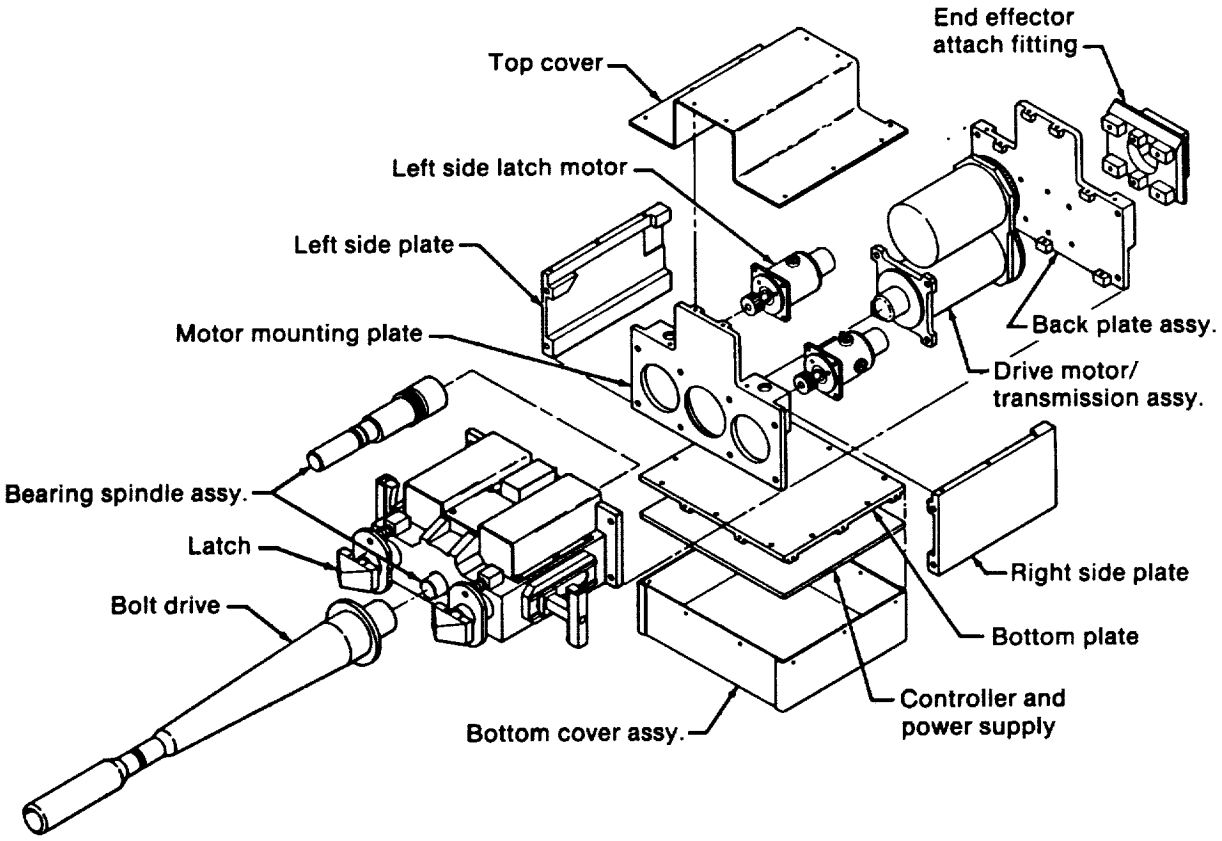
LIGHT-WEIGHT MODULE SERVICING TOOL

CONTACTS

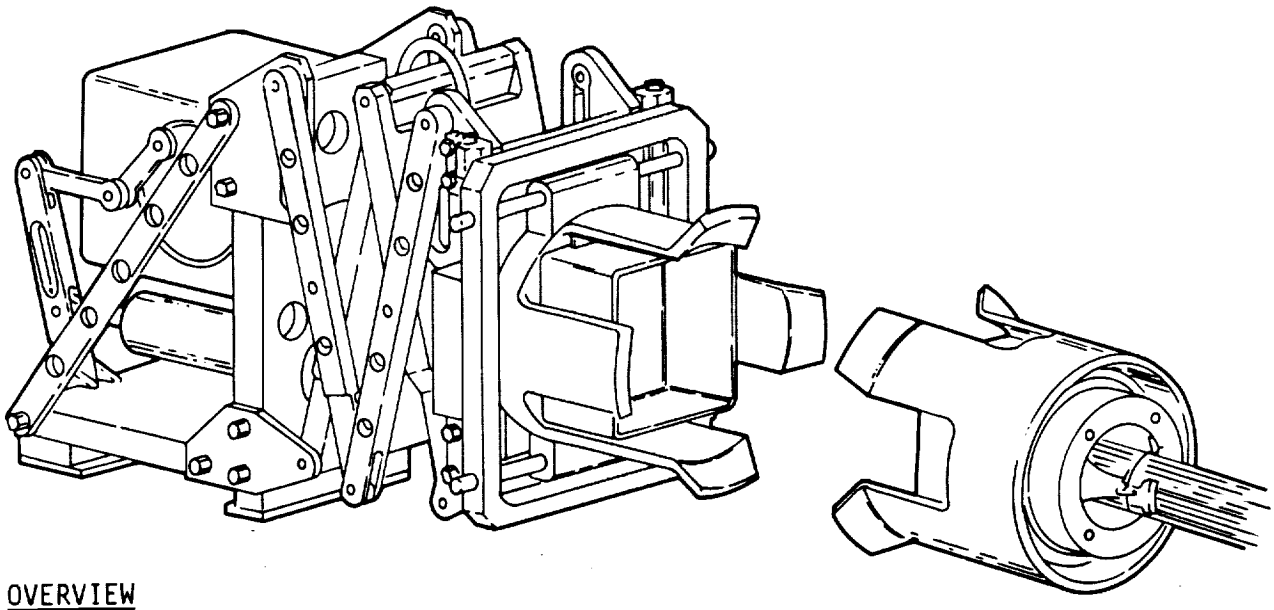
Source: R. E. Davis, NASA/GSFC SSP/Code 408.0, (301)286-2260
Operational: R. E. Davis, NASA/GSFC SSP/Code 408.0, (301)286-2260

Technical Information	
Part Number	TBS
Weight	Approx. 30 lbs.
Power	External 28 VDC operation for motors, TLM, and CMD
Status	Phase B design with phase C/D hardware FO
Materials	Structure - aluminum
Temperature Range	-50 to +100 deg. F; degr -100 to +250 deg. F
Pressure	Min. 10^{-10} Torr
Operations	Intermittant over 4 yrs with minor servicing

Interface Details	
Interface Device	Integrated orbital servicer system end effector or optional RMS Lt-Wt EGF
Precapture Misalignment Limits	TBD" pitch/yaw radius 0.5" axial +/- TBD deg all attitudes
Electrical Connector	XX-contact modified subminiature "D" Connector
Cable Type	Interconnections via RMS/ manipulator/robotic system
Type OPNS	Mission specialist contrs RMS and MST from Aft Flt deck controllers/panels
Bolt Torque	Selectable to MAX 220 Ft-Lbs



Linear Remotely Operated Electrical Umbilical



OVERVIEW

The Linear Remotely Operated Electrical Umbilical (LROEU) is an electrical umbilical concept to accommodate payloads which do not exhibit large orbiter/payload misalignments in X_O and Y_O. The LROEU incorporates the Flight Support System umbilical proven concept and the Remotely Operated Electrical Umbilical (ROEU) alignment features.

OPERATIONAL COMMENTS AND INTERFACE PROVISIONS

Compact disconnect system may be mounted in a variety of orbiter locations to accommodate payloads with restricted access to umbilical connectors. Normal mounting is on Port or Starboard bridge rail. Provides self alignment of orbiter/payload portions of disconnect.

STATUS

Concept

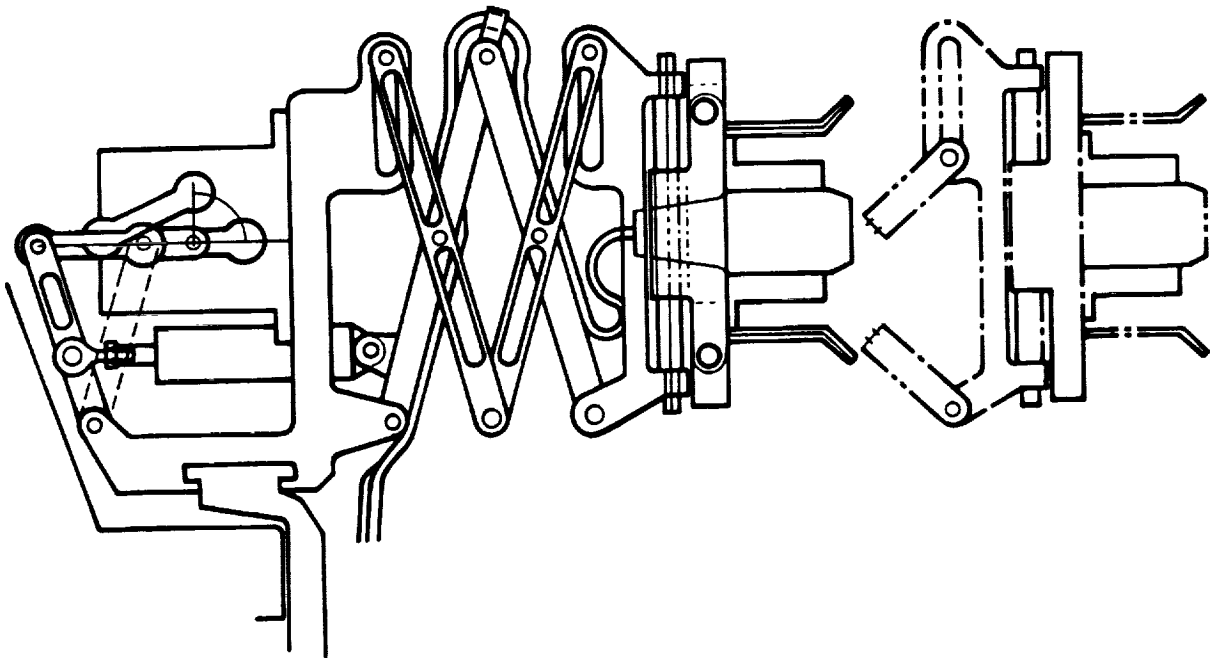
CONTACTS

Source: Rockwell International, 12214 Lakewood Blvd., Downey, CA 90241
Operational: C. W. Anderson, (213)922-5095
R. L. Gasteiger, (213)922-5339

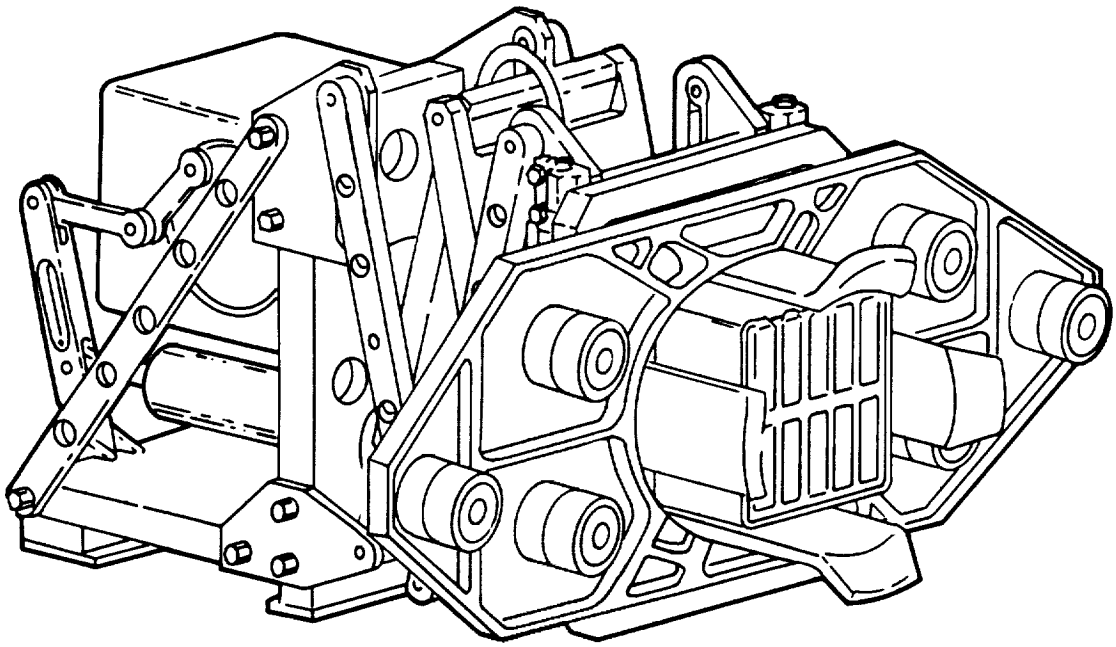
LROEU - LONGERON MOUNTING

Technical Information	
Weight	<25 lbs.
Power Req	TBD
Temp Range	TBD
Cooling	N/A
Material	Aluminum
Status	Concept

Interface Details	
Electrical	28 V dc
Mechanical	TBD
Data Rate	N/A
Documentation	TBD



Linear Remotely Operated Electrical/Fluid Umbilical



OVERVIEW

The Linear Remotely Operated Electrical/Fluid Umbilical (LROEFU) is an electrical/fluid umbilical concept to accommodate payloads which do not exhibit large orbiter/payload misalignments in X_O and Y_O. The LROEFU incorporates the Flight Support System umbilical proven concept and the Remotely Operated Electrical Umbilical (ROEU) alignment features.

OPERATIONAL COMMENTS AND INTERFACE PROVISIONS

Compact disconnect system may be mounted in a variety of orbiter locations to accommodate payloads with restricted access to umbilical connectors. Normal mounting is on Port or Starboard bridge rail. Provides self alignment of orbiter/payload portions of disconnect.

STATUS

Concept

CONTACTS

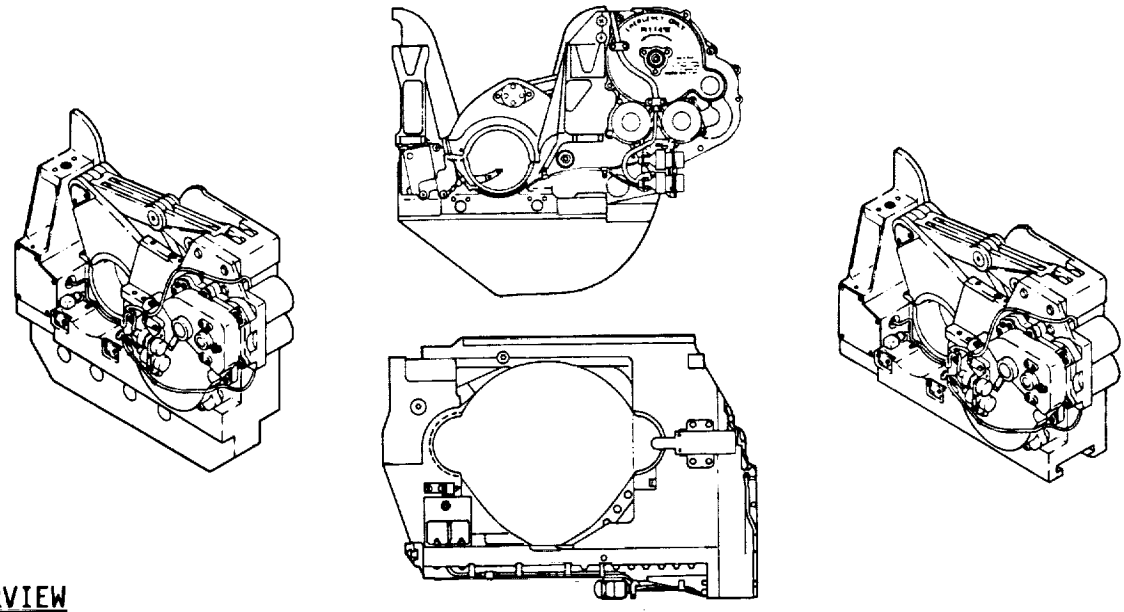
Source: Rockwell International, 12214 Lakewood Blvd., Downey, CA 90241
Operational: C. W. Anderson, (213)922-5095
R. L. Gasteiger, (213)922-5339

LROEFU - LONGERON MOUNTING

Technical Information	
Weight	<25 lbs.
Power Req	TBD
Temp Range	TBD
Cooling	N/A
Material	Aluminum
Status	Concept
Connector Insert	Accommodates approx 130 pins and selection of qualified fluid disconnects of various sizes.
Misalignment	± 0.5 inches
Conical Displacement	5°
Length of Stroke	9.15 inches

Interface Details	
Electrical	28 V dc
Mechanical	TBD
Data Rate	N/A
Documentation	TBD

Longeron and Keel Latches



OVERVIEW

The longeron and keel latches presented herein have been fabricated and are currently in the STS inventory and available to payload users. Characteristics and operational data are presented in both summary and unique formats.

OPERATIONAL COMMENTS AND INTERFACE PROVISIONS

See attached data.

STATUS

Each of the latches described are flight qualified and have flown on most STS missions.

CONTACTS

Source: Rockwell International, 12214 Lakewood Blvd., Downey, CA 90241
Operational: C. W. Anderson, (213)922-5095
R. L. Gasteiger, (213)922-5339

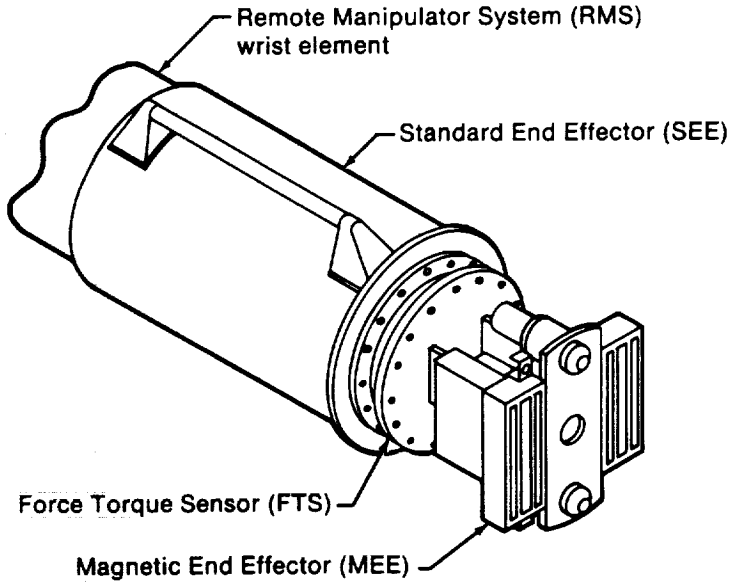
LONGERON AND KEEL LATCHES

PAYLOAD RETENTION LATCHES MAJOR CHARACTERISTICS			
LATCH DESIGNATION	LIMIT LOAD (POUNDS) (NOT SUMULTANEOUSLY)	WEIGHT (POUNDS)	DRAWDOWN CAPABILITY
STANDARD WEIGHT LONGERON LATCH	X = 121,000 Y = 12,100 Z = 121,000	113	15,000 POUNDS MAX.
MIDDLE WEIGHT LONGERON LATCH	X = 64,000 Y = 6,400 Z = 64,000	55	12,000 POUNDS MAX.
MODIFIED MIDDLE WEIGHT LATCH	X = 64,000 Y = 6,400 Z = 64,000	44	12,000 POUNDS MAX.
LIGHT WEIGHT LONGERON LATCH	X = 48,400 Y = 4,840 Z = 48,000	44	12,000 POUNDS MAX.
PASSIVE LONGERON LATCH	X = 121,000 Y = 12,100 Z = 121,000	28	N/A
STANDARD WEIGHT KEEL LATCH	X = 6,800 Y = 73,690 Z = 7,370	80	1,000 POUNDS
LIGHT WEIGHT KEEL LATCH	X = 2,500 Y = 25,000 Z = 2,500	44	1,000 POUNDS

Magnetic End Effector

OVERVIEW

The Magnetic End Effector (MEE) with force feedback is a proposed attachment for the Remote Manipulator System (RMS) which improves dexterity.



OPERATIONAL COMMENTS AND INTERFACE PROVISIONS

The MEE with force feedback is designed to be attached to the end of the RMS using an Electrical Flight Grapple Fixture (EFGF). The hardware consists of a force-torque sensor sandwiched between the EFGF and the MEE. The force torque sensor detects forces and moments being exerted at the end of the RMS and sends data to a computer and video graphics generator on the Aft Flight Deck. The RMS operator can monitor these forces on a CRT display. The Magnetic End Effector is designed to grapple objects which have a simple, flat strike plate of ferrous material. In addition, the MEE will have the capability to transfer data across the interface by means of an optical data link and to transfer power. The MEE is equipped with both a centerline TV camera and a camera oriented 90 degrees from the centerline camera. The MEE will be particularly useful in handling items which must be stacked flat and which cannot accomodate the standard grapple fixture. An example of such items are the heatpipes to be used on the Space Station and to be flown as part of the SRAD experiment. Other examples would be various tools and construction materials. The MEE and force-torque sensor will be stowed on their own carrier mounted shelf, using a unique latching mechanism.

STATUS

The concept and hardware/software described above were a joint development of JPL and JSC. A training version of the MEE and the force-torque sensor has been delivered to the Manipulator Development Facility at JSC. The hardware/-software has been checked out and used to demonstrate increased dexterity of the MDF arm under several conditions. One of the demonstrations involved inserting a two foot long probe, with a hex head socket attached, into a guide tube and applying a specified amount of torque to a bolt at the bottom of the tube.

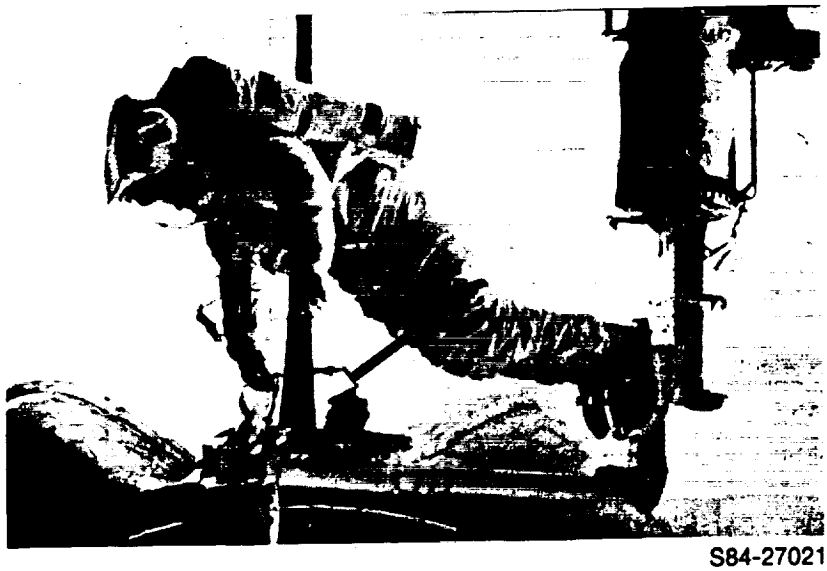
MAGNETIC END EFFECTOR

The current effort includes additional tests/demonstrations using the MDF unit and the preliminary design of a flight version. Funding has not been identified to support actual development of the flight version.

CONTACTS

Source: JPL and JSC
Operational: L. Monford, NASA JSC/IC, (713)282-1809

Manipulator Foot Restraint



S84-27021

OVERVIEW

The Manipulator Foot Restraint (MFR) is a crewmember restraint device and work station which is grappled by the Remote Manipulator System (RMS). It consists of a lower base with a standard RMS grapple fixture and a latch and roller assembly for attaching the MFR to the Adaptive Payload Carrier (APC). On top of the lower base is the MFR base, supporting the foot restraint platform and vertical stanchion. The upper portion of the stanchion, the work station, includes handholds, space for two removable tool boards, and the Payload Interface Mechanism (PIM). A safety tether is attached to the foot restraint platform for crewmember use. Several parts of the MFR rotate to provide a wide range of crewmember motion.

OPERATIONAL COMMENTS AND INTERFACE PROVISIONS

The MFR provides for EVA crewmember translation, positioning, and restraint in cargo bay worksites within reach of the RMS. Positioning of the MFR is by voice link with the RMS operator in the cabin.

STATUS

Flight qualified. Flown on specific flights.

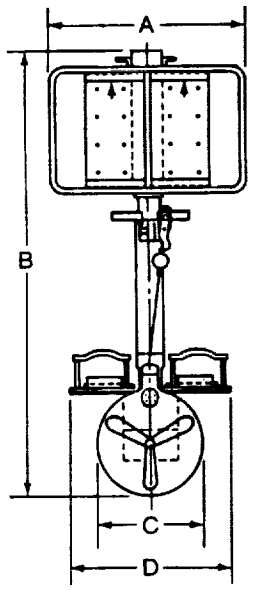
CONTACTS

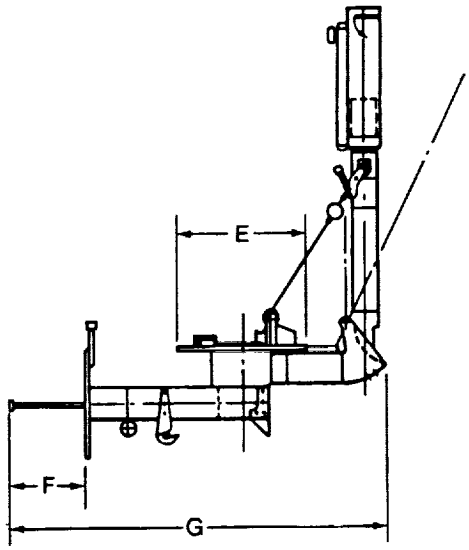
Source: T. W. Anderson, NASA/ES6, (713)483-8959
Operational: R. C. Trevino, NASA/DF4, (713)483-2597

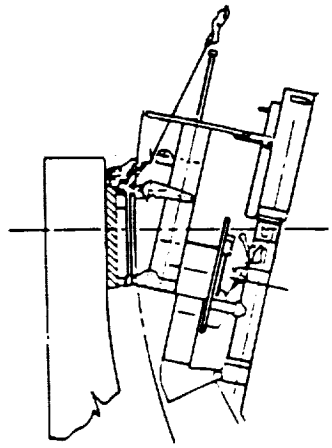
MANIPULATOR FOOT RESTRAINT

Technical Information	
Part Number	SED33103150-305
Weight	102 lb
Material	Primarily aluminum
Rotation of MFR base including vertical stanchion	±180° with locking in 45° increments
Tilt of stanchion away from crewmember	27° forward with locking in 9° increments
Rotation of work station about vertical stanchion axis	±180° with locking in 45° increments
Rotation of foot platform independent of base	Continuous 360° with locking in 30° increments
Stowage	Cargo bay, attached to APC

Dimensional Data	
A	25 in.
B	61.5 in.
C	14 in.
D	20.55 in.
E	14.5 in.
F	8 in.
G	52.5 in.

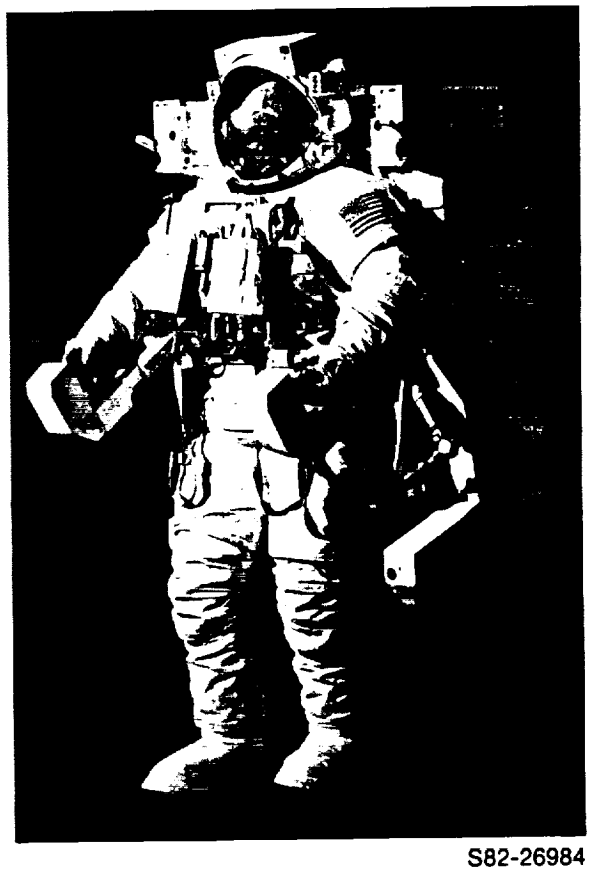






Manned Maneuvering Unit

OVERVIEW



S82-26984

The Manned Maneuvering Unit (MMU) is a modular self-supporting backpack, containing its own electrical power, propulsion system, and controls. It readily attaches to the Extravehicular Mobility Unit (EMU) and can be donned, doffed, and serviced by one EVA crewmember for use as required during a nominal 6-hour EVA. It has complete six-degree-of-freedom control authority and automatic attitude hold capability. It provides attachment points for the use of ancillary equipment such as satellite docking mechanisms, tools, portable lights, cameras, and instrument sensors. The propellant is gaseous nitrogen, which in noncontaminating.

OPERATIONAL COMMENTS AND INTERFACE PROVISIONS

The MMU is used to increase the EVA crewmember's mobility by extending the range of activities from the cargo bay to other portions of the spacecraft, to appendages of payloads protruding from the cargo bay, or to other spacecraft. It can be used to carry cargo of moderate size, to stabilize satellites, to retrieve small free-flying payloads, and to provide remote photography/television of Shuttle operations.

Two MMU's are normally manifested. On past missions, the MMU has been used with the Apogee Kick Motor Capture Device (ACD), the trunnion pin attachment device (TPAD), and MMU camera provisions. The MMU is stowed in the forward cargo bay (1) on the flight support station (FSS) designed specifically for that purpose.

STATUS

Flight qualified. Flown on specific flights.

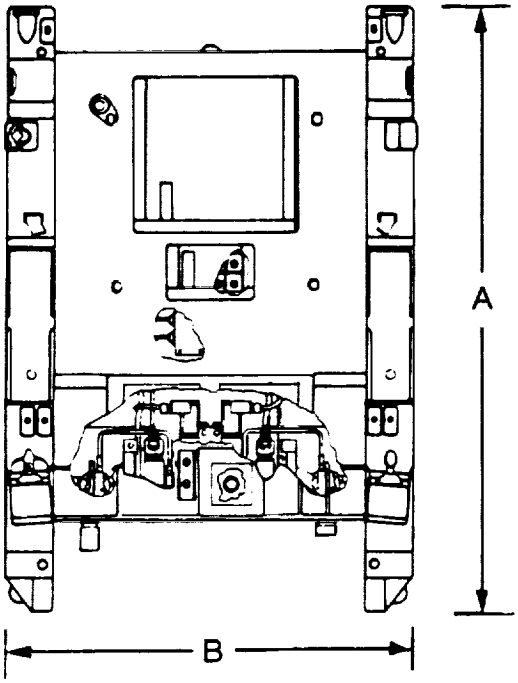
CONTACTS

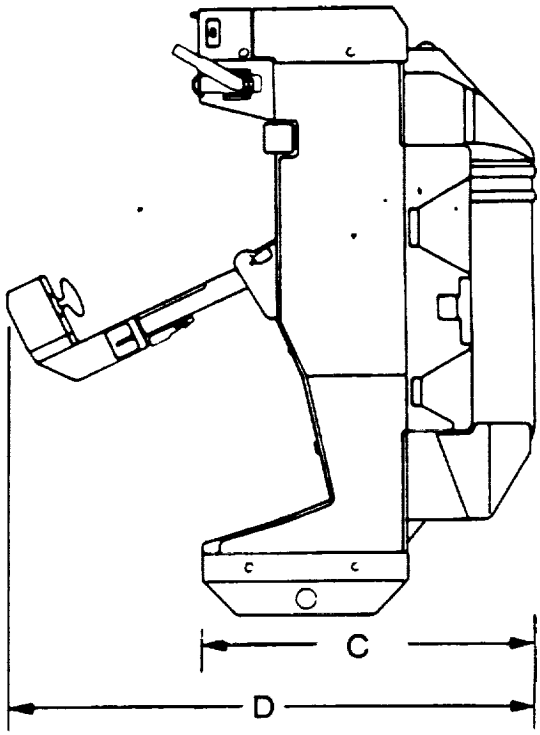
Source: L. J. Rogers, Martin Marietta, Denver, CO, (303)977-3669
Operational: C. E. Whitsett, NASA/JSC/EC, (713)483-9111

MANNED MANEUVERING UNIT

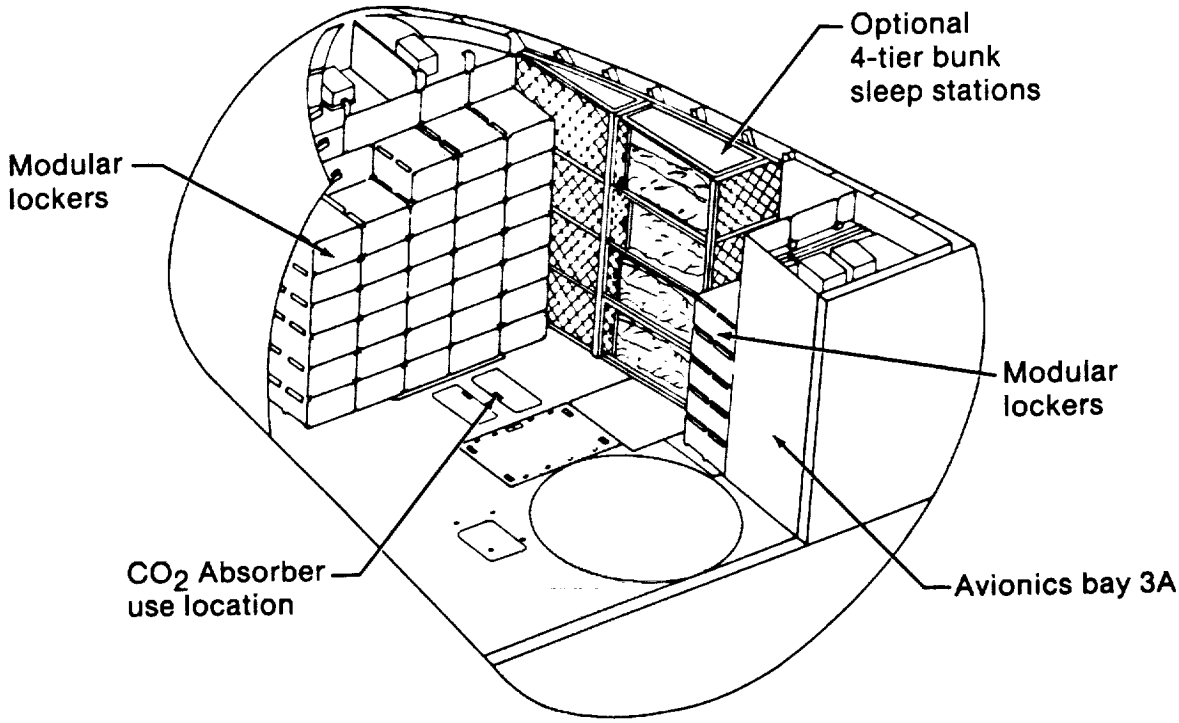
Technical Information	
Part Number	852MU000000
Weight	338 lb
Material	Aluminum
Control	Three modes of operation - manual, automatic attitude hold, and satellite stabilization Left hand controller - 3DOF translation Right hand controller - 3DOF rotation Acceleration - approximately 0.2 to 0.4 ft/sec^2 Redundant logic
Maximum Range	Early flights - approximately 300 ft Potential - approximately 3000 ft
Electrical Power	Two batteries: total power - 852 W-hr
Propellant	Gaseous nitrogen Reservicing in less than 10 min
Stowage	Forward cargo bay on FSS

Dimensional Data	
A	50.0 in.
B	33.3 in.
C	27.0 in.
D	48.0 in.

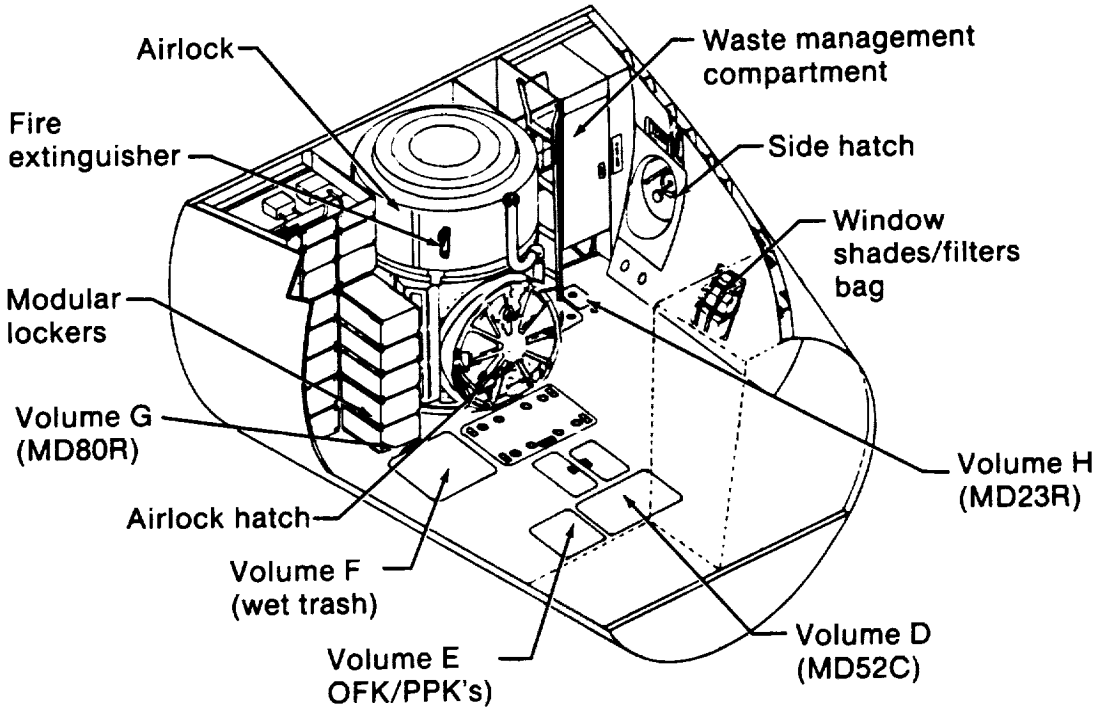




Middeck



Middeck (Forward)



Middeck (Aft)

MIDDECK

OVERVIEW

The Orbiter Middeck contains D&C panels for Orbiter systems control, stowage provisions for most of the crew equipment on a flight, a waste management system compartment, the airlock, and middeck floor stowage compartments. Beneath the middeck, the lower equipment bay contains Environmental Control and Life Support System (ECLSS) hardware. Access to equipment in the lower equipment bay is through Middeck floor panels which are marked with Middeck codes.

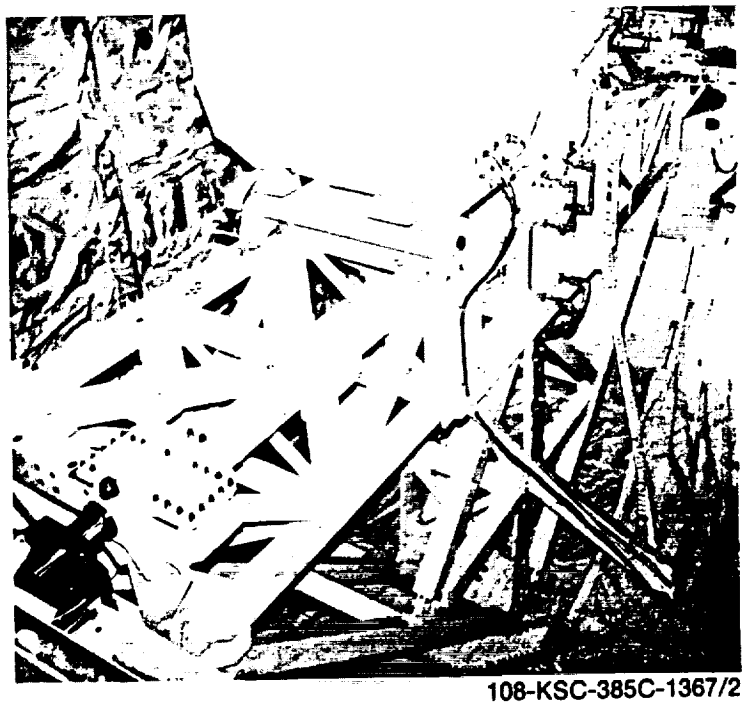
OPERATIONAL COMMENTS AND INTERFACE PROVISIONS

The Middeck has provisions for up to 42 modular lockers each containing such items as experiments, food, and nominal and contingency equipment. In addition, provisions exist for the waste management system, galley and sleep stations. The ECLSS is contained beneath the Middeck and equipment bay. Contingency access to the ECLSS is provided by means of removable floor panels. LiOH canisters and the wet trash compartment are also located there.

STATUS

The Middeck is an integral part of the Shuttle Orbiter.

Mission Peculiar Equipment Support Structure



108-KSC-385C-1367/2

OVERVIEW

The Mission Peculiar Equipment Support Structure (MPESS) provides support for experiments and/or instruments in the Orbiter Cargo Bay during Space Shuttle flights.

OPERATIONAL COMMENTS AND INTERFACE PROVISIONS

The MPESS is connected to the Cargo Bay by means of trunnion fittings on each end and a keel fitting at the bottom. There are no preintegrated electrical, environmental, or command and data management subsystems. The structural arrangement provides reasonable access for experiment installation and removal.

STATUS

The MPESS is flight qualified for STS operations.

CONTACTS

Source: George C. Marshall Space Flight Center, (205)453-2121
Operational: Jim Turner/NASA MSFC/PS-01, (205)544-0617

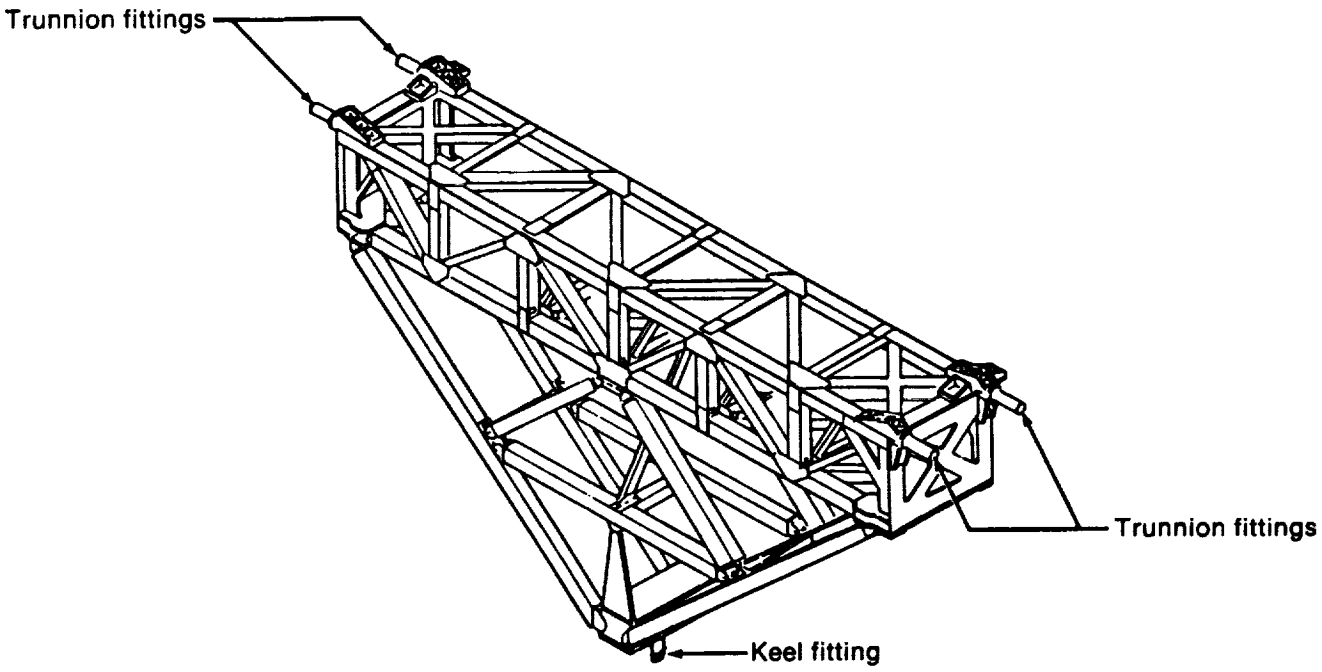
REFERENCES

Design and Performance Specification CE Part 1 MPE Support Structure CE #F 43001A

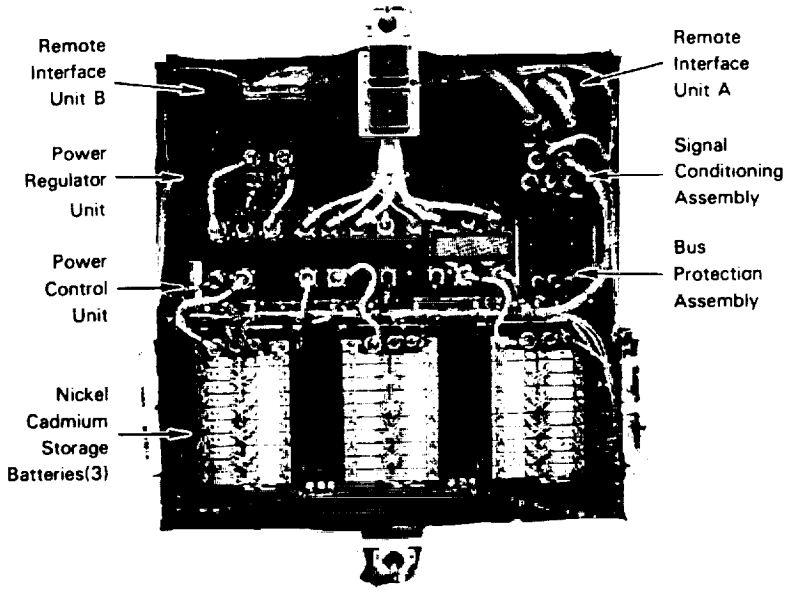
MISSION PECULIAR EQUIPMENT SUPPORT STRUCTURE

Technical Information	
Weight	1,185 lb
Material	2219-T85 and 6061-T6 Aluminum Alloy

Dimensions	
Length	173.5 in.
Width	27.5 in.
Height	109.0 in.



Modular Power Subsystem



OVERVIEW

The Modular Power Subsystem provides a compact, cost-effective, modular power management system which conditions, stores, and distributes electrical power to onboard satellite systems.

OPERATIONAL COMMENTS AND INTERFACE PROVISIONS

The six major internal components of the MPS (shown in the photograph) perform separate but equally important tasks. The power regulator unit draws energy from solar arrays and conditions it for satellite use. The power control unit directs the energy flow to the nickel cadmium storage batteries (for use during portions of the orbit when sunlight is not available) and directly to the satellite's equipment or experiments. The signal conditioning assembly handles the command and telemetry signals that control and monitor the functions of the MPS. The two remote interface units channel these signals to and from the spacecraft's computer. The bus protection assembly provides fuse protection for loads within the MPS.

STATUS

The MPS is being used on the Solar Maximum Mission Satellite, launched in 1980, and Landsats 4 and 5, launched in 1982 and 1984. Two more MPS modules will provide power conditioning on NASA's new Gamma Ray Observatory spacecraft.

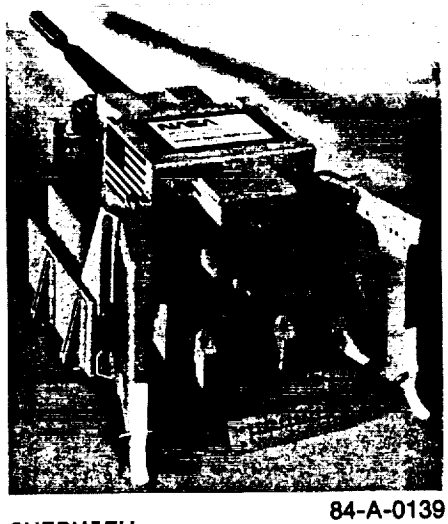
CONTACTS

Source: McDonnell Douglas, St. Louis Division, (314)232-0232
Operational: Michael Mackowski, (314)233-2364

MODULAR POWER SUBSYSTEM

Technical Information	
Size	4 x 4 x 1.5 foot Aluminum honeycomb housing
Self-contained module	

Module Servicing Tool



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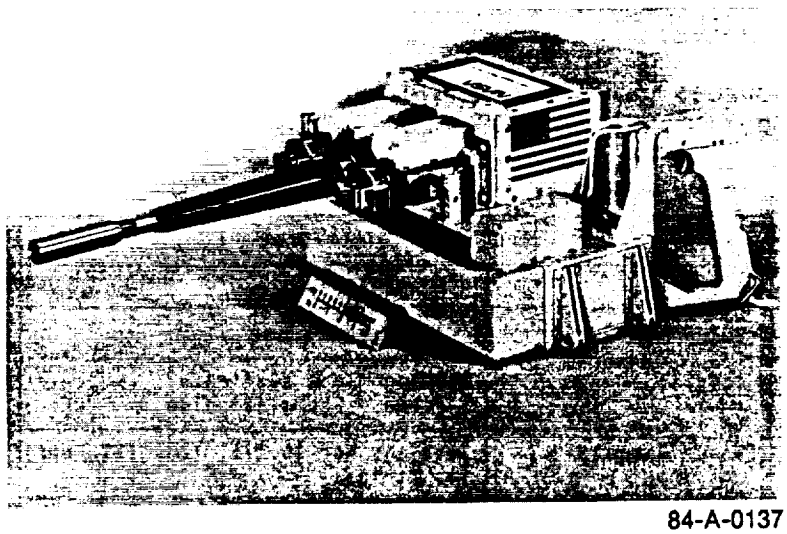


84-A-0137

OVERVIEW

The Module Servicing Tool (MST) is a self-contained power tool used to install and remove standard Multimission Modular Spacecraft (MMS) subsystem modules. It is intended to simplify and reduce the time required for extravehicular, on-orbit maintenance and repair operations.

OPERATIONAL COMMENTS AND INTERFACE PROVISIONS

The MST is an Extravehicular Mobility Unit (EMU) battery-powered, extra-vehicular activity (EVA) tool. It is designed to loosen and tighten the MMS module retention bolts to predetermined torques of up to 160 ft-lbs. Controls for manual operation of the MST are located on the rear panel and left and right grip assemblies. A torque limit switch is available to select the desired torque for bolt tightening and loosening. In addition, the MST has a bolt drive counter which provides the operator with a visual indication of bolt drive rotation direction and bolt tightening completion. A separate control circuit provides power to two resistance heaters which thermostatically maintain the minimum battery temperature. Separate external heaters are required to maintin MST battery temperatures prior to EVA use. The MST is battery-powered and manually operated, and therefore, does not have any Space Transportation System power or signal interfaces. Two MST's were flown on STS-41C and were used during the successful exchange of the attitude control system module of the Solar Maximum satellite.

STATUS

Flight units: Two flight qualified units are available

Engineering unit: Available for one gravity dry-land and KC-135 aircraft training and demonstration

Underwater training unit: Available for training and demonstration

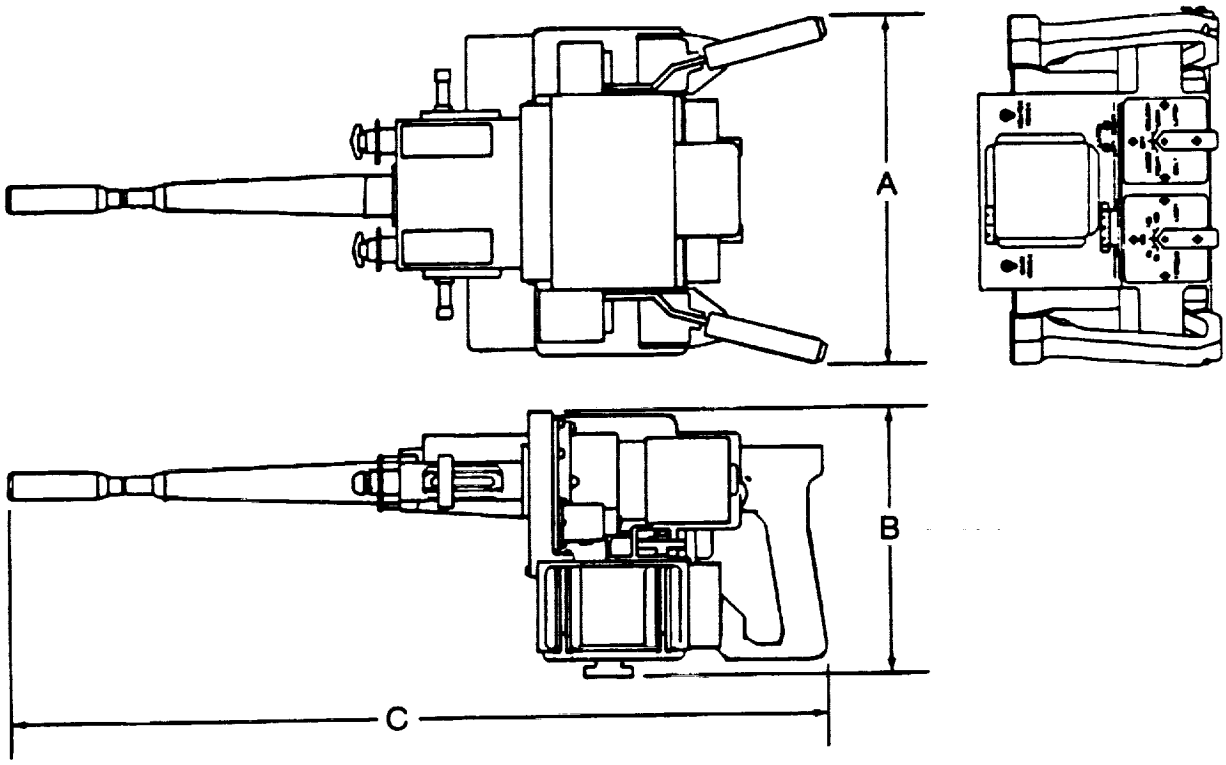
MODULE SERVICING TOOL

CONTACTS

Source: GSFC, Fairchild Space Company, (301)286-2000
Operational: R. Lewis or K. Rosette, NASA/GSFC, Code 408, (301)286-2060, (301)286-7201

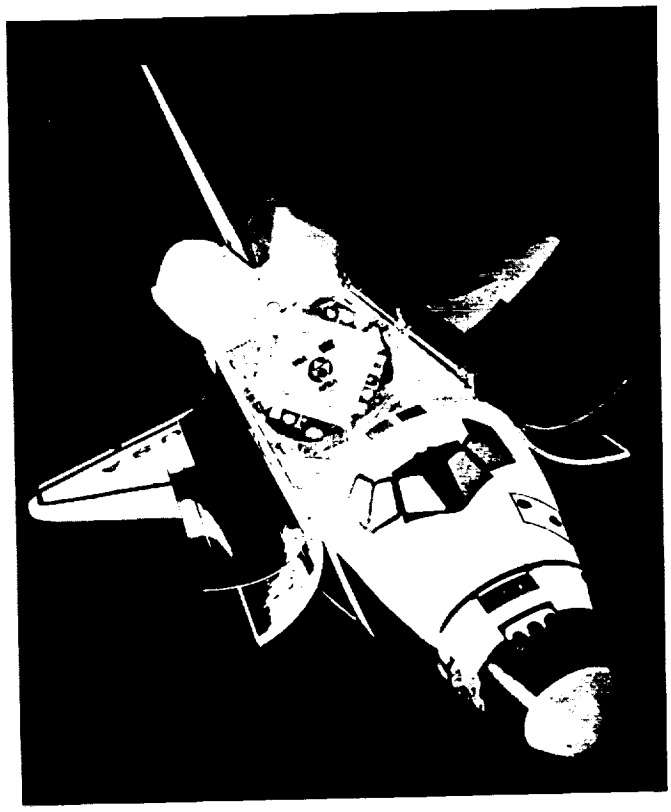
Technical Information	
Part Number	GSFC 93972000002
Weight	70.5 lb
Material	Housing - not available Surface - Chemglaze blue
Torque Range	Settings for 25, 75, 100, 125, and 160 ft-lbs.
Temperature Range	-10°F to 104°F
Power Requirements	16.5 V EMU battery

Dimensions (Inches)	
A	14.75 in.
B	14.32 in.
C	35.20 in.



Orbital Maneuvering Vehicle

OVERVIEW



The Orbital Maneuvering Vehicle (OMV) provides for the extension of payload services and capabilities out of the Orbiter and the Space Station. these services include spacecraft delivery and retrieval to and from higher orbits, reboost or deboost, payload viewing and satellite support. The OMV will also be capable of supporting advanced mission kits for remote servicing, refueling, and debris retrieval.

OPERATIONAL COMMENTS AND INTERFACE PROVISIONS

The OMV will have the capability of performing delivery, retrieval, reboost, deboost and viewing missions from both the Orbiter and Space Station. On-orbit operations may be controlled either from the ground or the Space Station. Space Station operations typically will be controlled by the Space Station operator when the OMV is operating in close proximity of the station. In either case, final docking maneuvers are performed by remote piloted modes. Cold gas propulsion will be utilized for final docking and proximity operation maneuvers near contamination sensitive payloads. The OMV will be capable of a nine month storage period in the event the orbiter has to return to the ground prior to OMV return to the orbiter. The OMV will be designed to accommodate on-orbit maintenance and will have a design life of 10 years with ground refurbishment. OMV payload accommodations are available in the form of structural support, power, data and command. Electrical power will be available up to 5 kw at a peak of 1 kw.

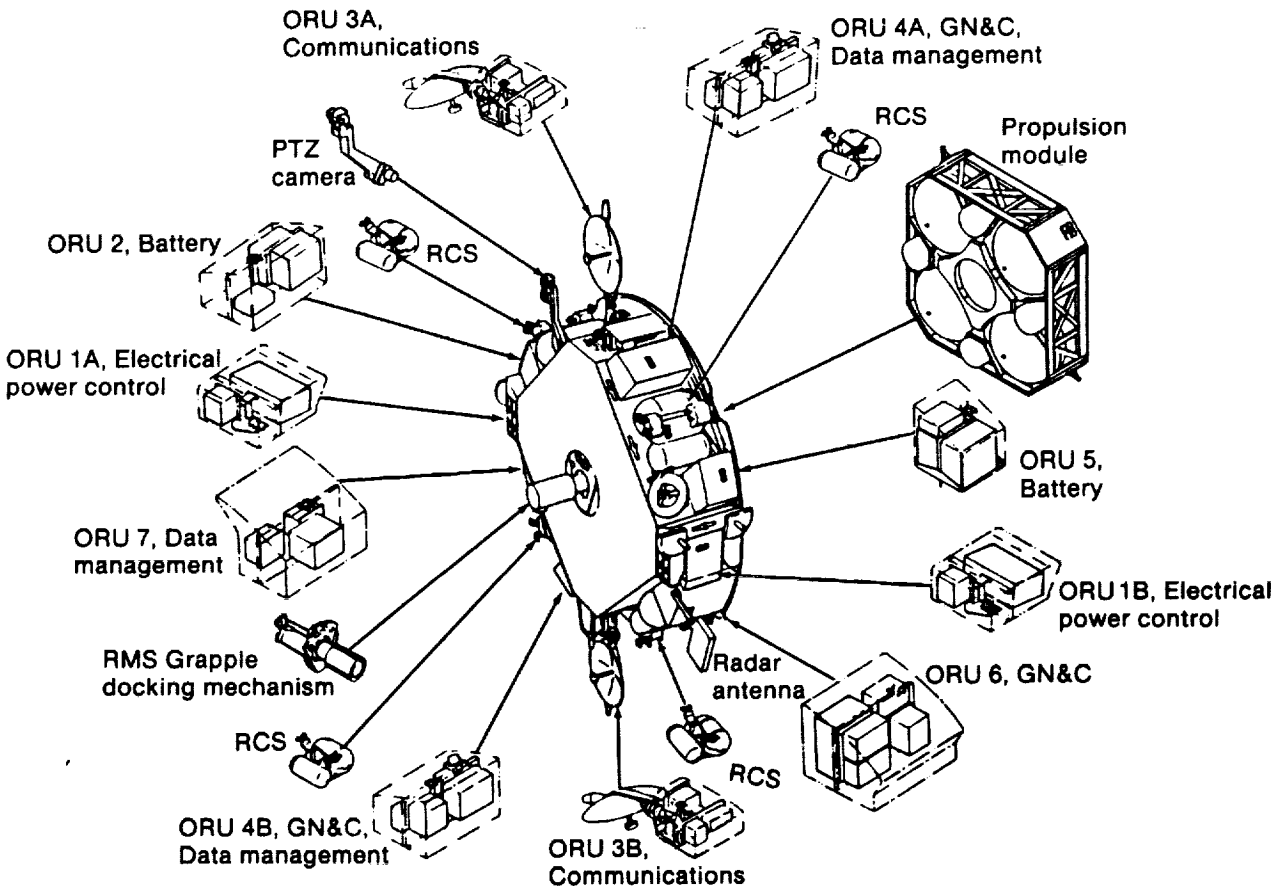
STATUS

Presently in the fabrication stage.

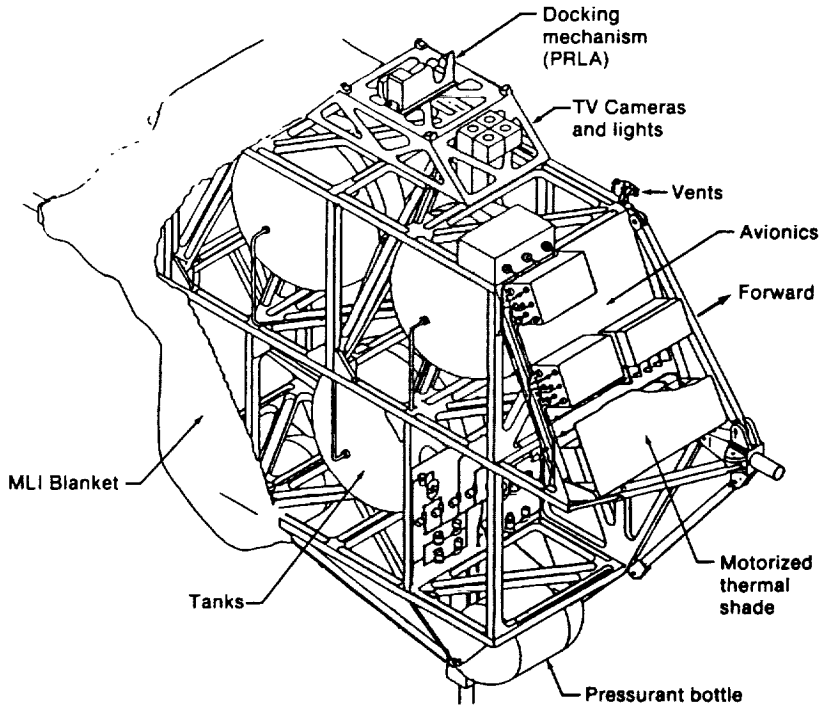
CONTACTS

Source: TRW Space and Technology Group
Operational: James R. Turner, NASA/MSFC, (205)453-2817

ORBITAL MANEUVERING VEHICLE



Orbital Spacecraft Consumables Resupply System



OVERVIEW

The Orbital Spacecraft Consumables Resupply System (OSCRS) is designed to be flexible in order to service a wide range of satellites and be adaptable to support Space Station. OSCRS will also provide adequate data and control to permit independent crew operation/trouble shooting/work-around without ground coverage.

OPERATIONAL COMMENTS AND INTERFACE PROVISIONS

Preliminary fluid quantities include Monopropellant and Bipropellant (conceptual design).

A. Monopropellant OSCRS Requirements

- Basic System
  - Resupply up to 2910 lb. of Hydrazine
  - Standard Orbiter interfaces
  - Operational after one failure
  - Safe after two failures
  - Design for a life of 80 flights
  - Manual connection to the satellite being serviced
  - Emergency separation of satellite without EVA
  - Vent propellant and/or gas from OSCRS and the satellite

ORBITAL SPACECRAFT CONSUMABLES RESUPPLY SYSTEM

- Basic Growth System

  Resupply up to 4850 lb. of Hydrazine

  Resupply high pressure gas (up to 3000 psi) 250 lb. of GN_2 or 36 lb. of GH_E

- Future Growth System

  Resupply high pressure gas (3000 to 5000 psi)

  Operate more than one fluid resupply system from the AFD on a single mission

  Automatic mating/demating of fluid and electrical disconnects

  Resupply spacecraft from an OSCRS attached to OMV or space station

B. Bipropellant OSCRS Requirements

- Basic System

  Resupply up to 7695 lb. of MMH and NTO

  Resupply up to 270 lb. of GN_2 at up to 4500 psi

  Other - Same as Monopropellant

- Basic Growth System

  Resupply up to 11542 lb. of MMH and NTO

  Resupply up to 630 lb. of GN_2 at up to 4500 psi

- Future Growth System

  Operate more than one fluid resupply system from the AFD on a single mission

  Automatic mating/demating of fluid and electrical disconnects

  Resupply spacecraft from an OSCRS attached to OMV or space station

STATUS

Presently in the technology development stage.

CONTACTS

Source: Rockwell International
Martin Marietta Corporation
Fairchild Space Company

Operational: R. Gasteiger, RI, (213)922-5339
Ralph Eberhardt, MMC, (303)977-4183
I. M. Leiy, Fairchild, (301)428-6951

ORBITAL SPACECRAFT CONSUMABLES RESUPPLY SYSTEM

Technical Information		
Item	Monopropellant	Bipropellant
Design reference mission	GRO resupply	OMV resupply
Fuel quantity for mission	3000 LBM	7000 LBM
Tanks & quantity	3 TDRS	4 L-SAT +2 catch tanks
Tank volume	16.3 Ft^3 each	27.0 Ft^3 each
Gas bottles	2	4
Structure	2219-T87 machined truss	2219-T87 machined truss
Service life	80 missions	80 missions
Attachment to orbiter	3 point	5 point
Docking mechanism	PRLA or 3 FSS latches	PRLAA or 3 FSS latches
Mass fraction	.60	.70

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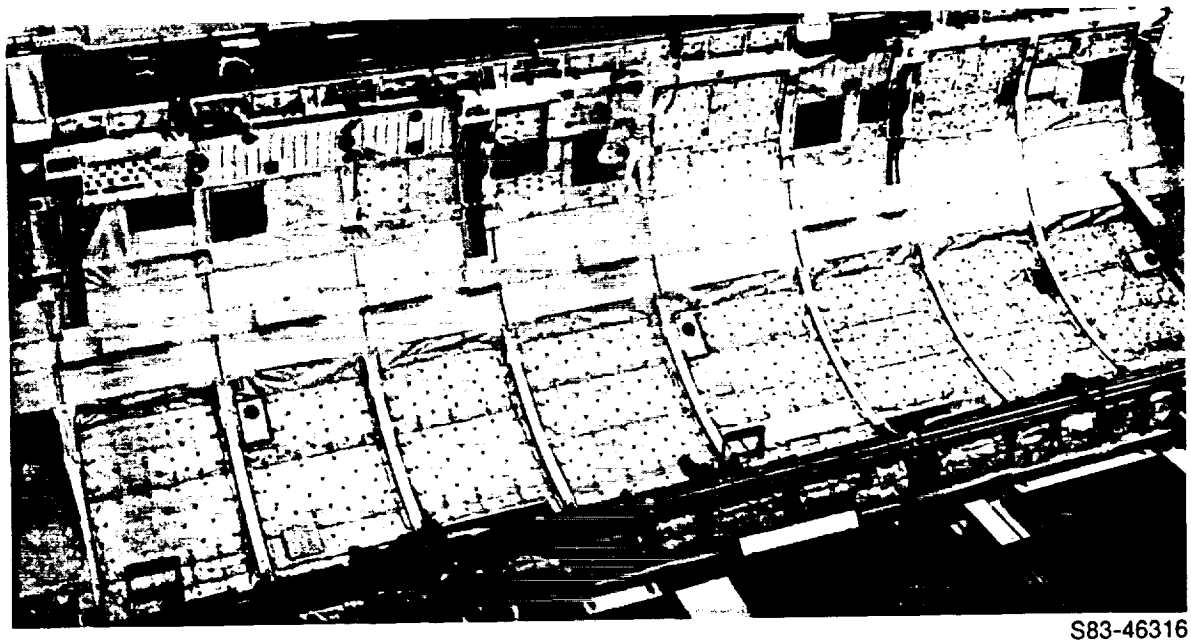
Orbiter Cargo Bay Floodlight System



S83-46316

OVERVIEW

Seven floodlights are provided in the Cargo Bay to aid extravehicular crew members in the performance of Cargo Bay door contingency operations; the lights are also integral to the launch, retrieval, and repair of various space systems.

OPERATIONAL COMMENTS AND INTERFACE PROVISIONS

Seven metal halide type lights provide a minimum of 7 ft-c of illumination at the Cargo Bay centerline; the forward bulkhead light provides the same level at 30 ft. There are some restrictions to activity near these lights because of the generated heat. In addition, some lighting may be blocked by payloads.

STATUS

Used on each flight since STS-1. Flight qualified.

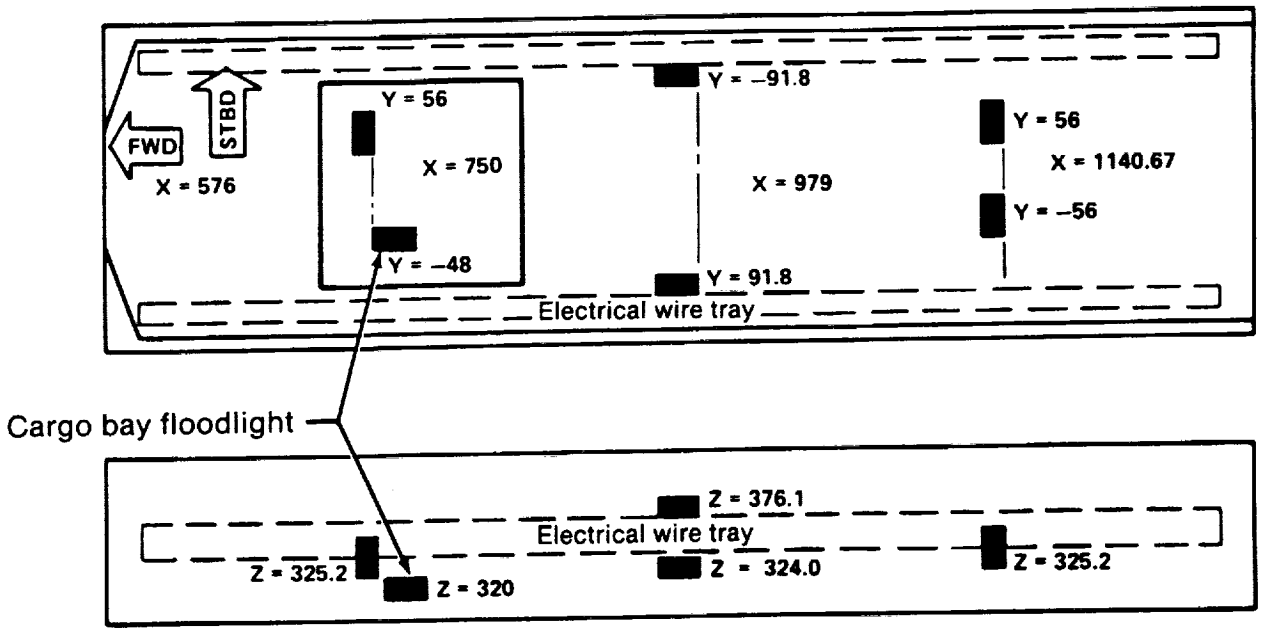
CONTACTS

Source: Rockwell/ILC Technology
Operational: C. D. Wheelwright/SP34, (713)483-3725

REFERENCES

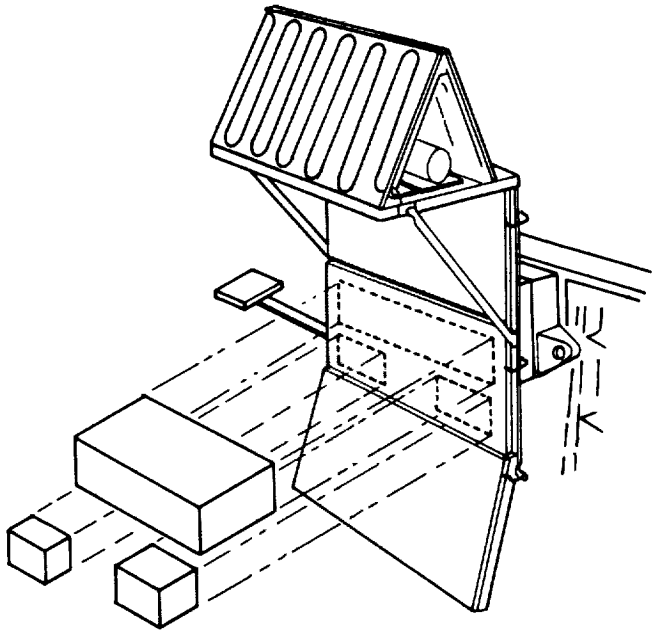
Space Transportation System: EVA Description and design criteria, Rev. A, JSC-10615

ORBITER CARGO BAY FLOODLIGHT SYSTEM



C-2

Payload Active Cooling/Heating System



OVERVIEW

The Payload Active Cooling/Heating System (PACS) is a self contained thermal control system mounted in the cargo bay on a sidewall carrier. The PACS is designed to accommodate small payloads or payload components with heat loads up to 8500 watts.

OPERATIONAL COMMENTS AND INTERFACE PROVISIONS

PACS modular design utilizing a lightweight structure, radiator panel, pump package, thermal plates and instrumentation may be used in an autonomous mode or with the payload orbiter cooling system.

STATUS

Concept

CONTACTS

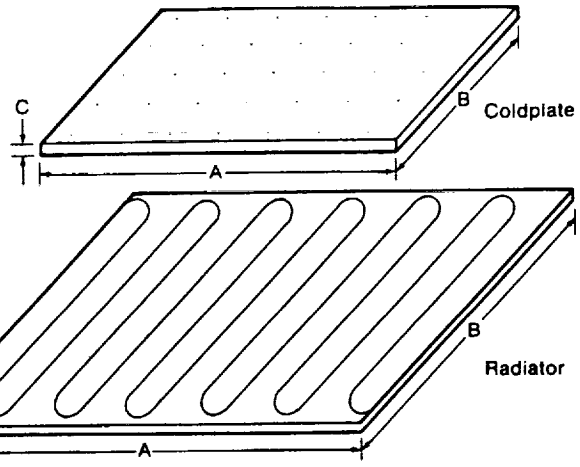
Source: Rockwell International, 12214 Lakewood Blvd., Downey, CA 90241
Operational: C. W. Anderson, (213)922-5095
R. L. Gasteiger, (213)922-5339

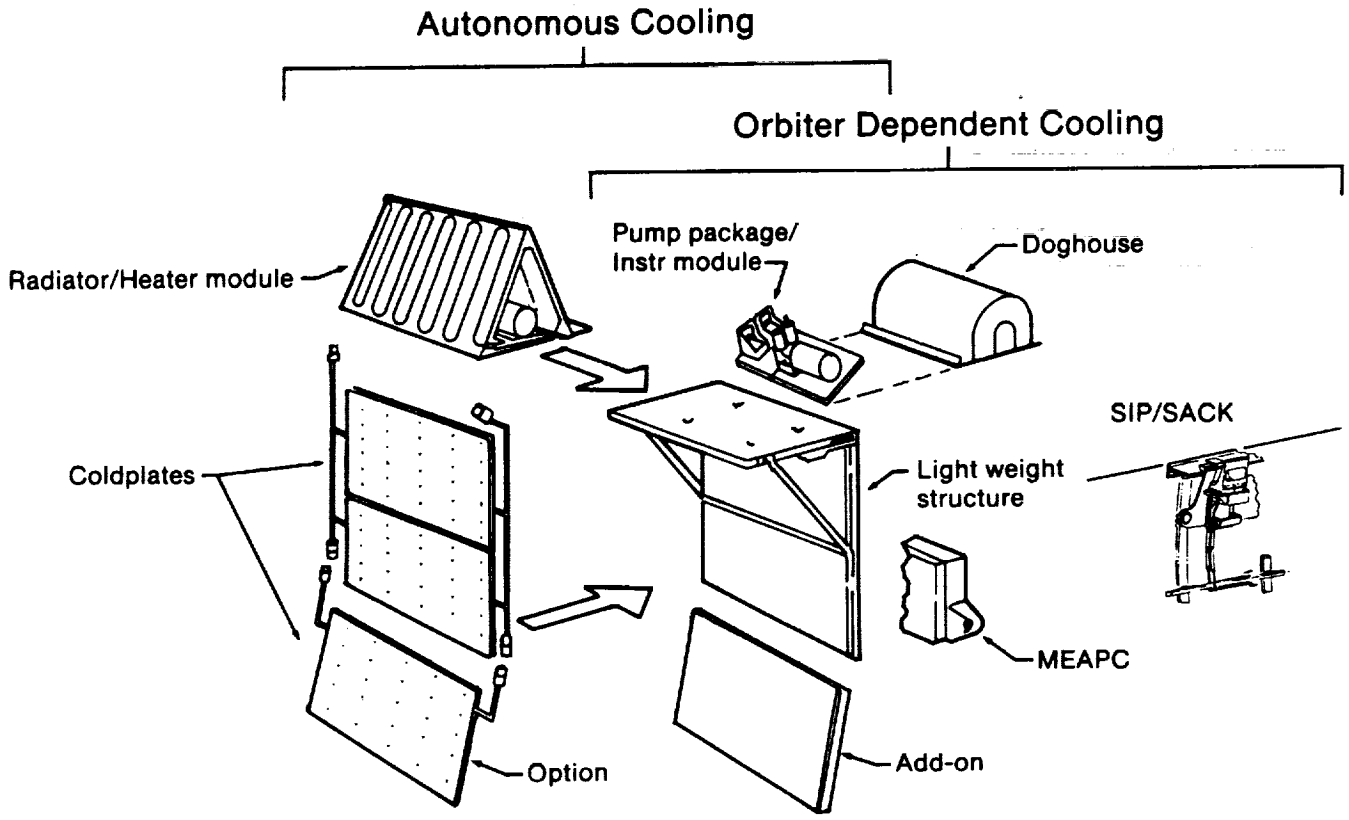
PAYLOAD ACTIVE COOLING/HEATING SYSTEM (PACS)

Technical Information	
Weight	<185 lbs
Power Req	28V dc. 80-500W depending upon pump speed and heater power
Temp Range	-250° to 250° F
Cooling	Coldplate maintained at 70° ± 4° F
Power	28VDC. 80-500 W
Material	TBD
Status	Concept

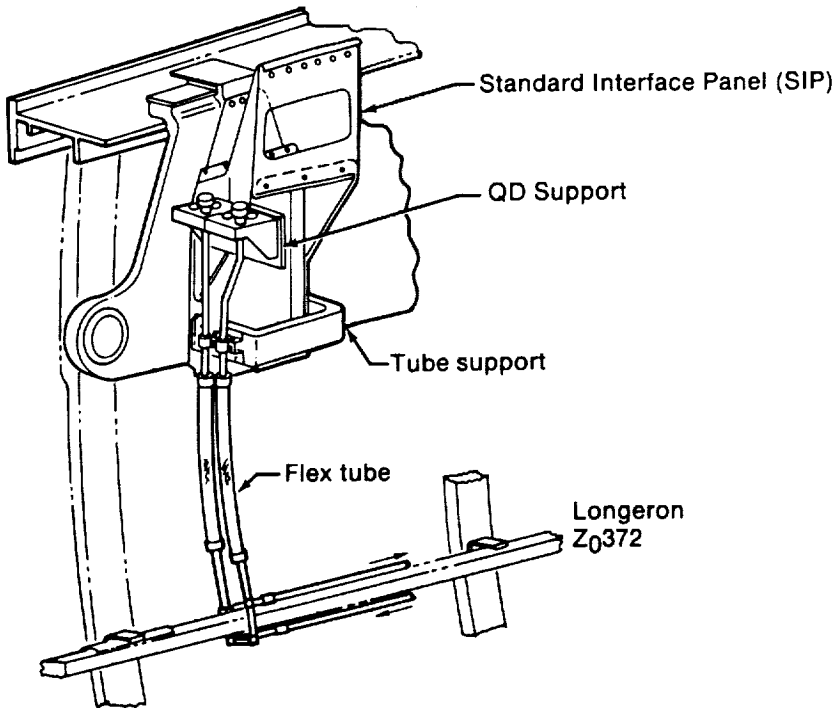
Interface Details	
Electrical	28V dc
Mechanical	Sidewall Mounted
Data Rate	N/A
Documentation	TBD

Dimensional Data		
Coldplate	A	40 in.
	B	20 in.
	C	1.4 in.
Radiator	A	50 in.
	B	36 in.





Payload Bay Standard Active Cooling Kit



OVERVIEW

The Payload Bay Standard Active Cooling Kit (SACK) provides cooling provisions to the lead payload in the orbiter.

OPERATIONAL COMMENTS AND INTERFACE PROVISIONS

Elements of kit hardware include:

- Quick disconnects for coolant supply and return at SIP interface
- Brackets and supports for fluid lines
- Fluid line segments
- Insulation blankets

This model establishes a standard interface for water or freon cooling systems at a SMCH-SIP panel (Model MV0725A).

STATUS

First used on STS-26.

CONTACTS

Source: Rockwell International, 12214 Lakewood Boulevard, Downey, CA 90241
Operational: R. Gasteiger, RI, (213)922-5339

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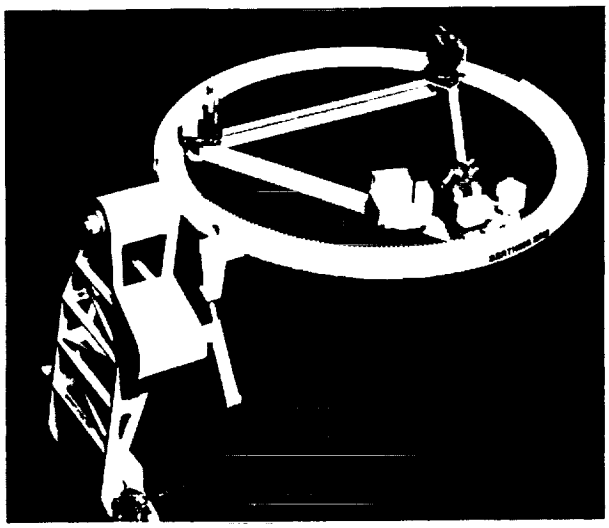
Payload Berthing System



A861010-V-4C

OVERVIEW

The Payload Berthing System (PBS) provides on-orbit docking/berthing of payloads for servicing, repair or temporary holding. The PBS is sidewall mounted at the primary attachment locations of bay 3 through 12.

OPERATIONAL COMMENTS AND INTERFACE PROVISIONS

The PBS utilizes the standard Flight Support System (FSS) interfaces, latches and umbilicals, and provides docking/berthing out of the confines of the cargo bay. The rotating berthing ring provides capability to access all side of a docked payload. The PBS may be deployed from the payload bay by EVA, RMS or motor. The PBS design provides the capability to support a 40,000 pound payload.

STATUS

Concept. Several design studies have been performed.

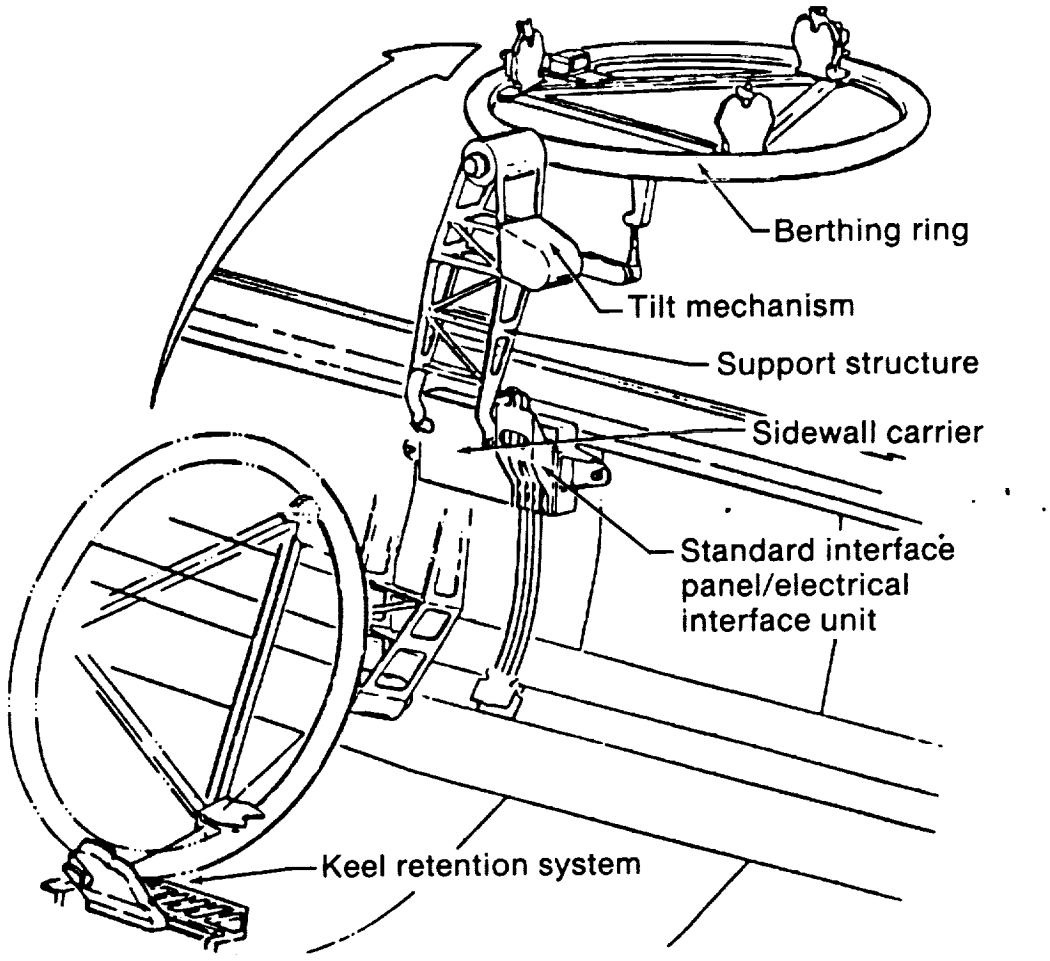
CONTACTS

Source: Rockwell International, 12214 Lakewood Blvd., Downey, CA 90241
Operational: C. W. Anderson, (213)922-5095
R. L. Gasteiger, (213)922-5339

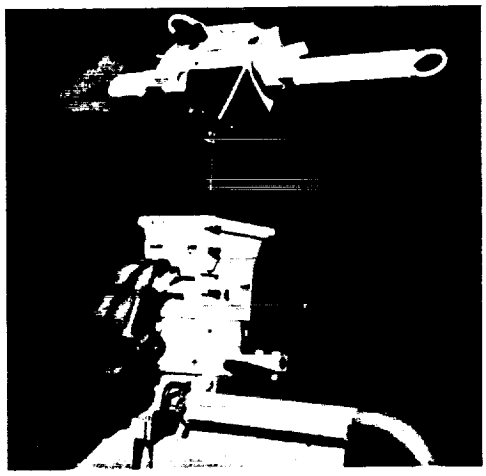
PAYLOAD BERTHING SYSTEM

Technical Information	
Weight	<1000 pounds
Power Req	TBD
Temp Range	TBD
Cooling	TBD
Material	Aluminum
Status	Concept

Interface Details	
Electrical	TBD
Mechanical	Sidewall mounted
Data Rate	N/A
Documentation	Design study report



Payload Interface Mechanism



S83-37182

OVERVIEW

The Payload Interface Mechanism (PIM) mounts on top of the Manipulator Foot Restraint (MFR) stanchion. It is a tethering device for attaching a payload to the MFR and consists of three main parts: a payload fitting, a pyramid fitting, and a pyramid housing. The pyramid fitting and the pyramid housing are connected by a retractable tether. Tether attachment rings are provided on the ends of the pyramid fitting's handles and on the payload fitting.

OPERATIONAL COMMENTS AND INTERFACE PROVISIONS

The PIM was designed for temporary stowage and transfer of the MST. The pyramid fitting attaches to the payload fitting mounted on the MST. Then the pyramid fitting and the MST are pulled over to the MFR and latched onto the pyramid housing. The MST is released from the PIM by turning the lock-unlock lever on the pyramid fitting and depressing the release levers on the payload fitting handles. The pyramid fitting is released from the pyramid housing by pushing the lock-unlock bar on the pyramid housing to the unlock position and depressing the housing latch handle.

STATUS

Flight qualified. Flown on specific STS flights.

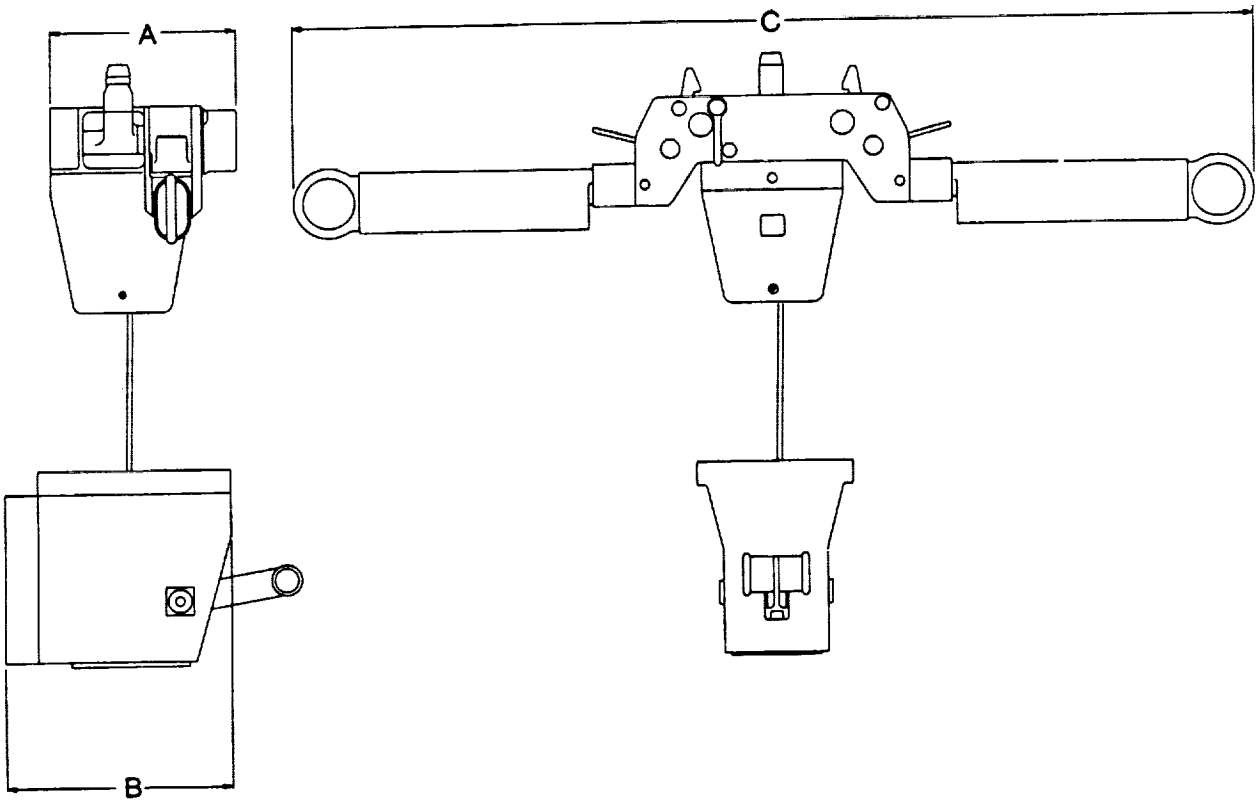
CONTACTS

Source: S. Abraham, Grumman Aerospace Corp., (516)575-9553
Operational: R. C. Trevino, NASA/JSC/DF, (713)483-2597

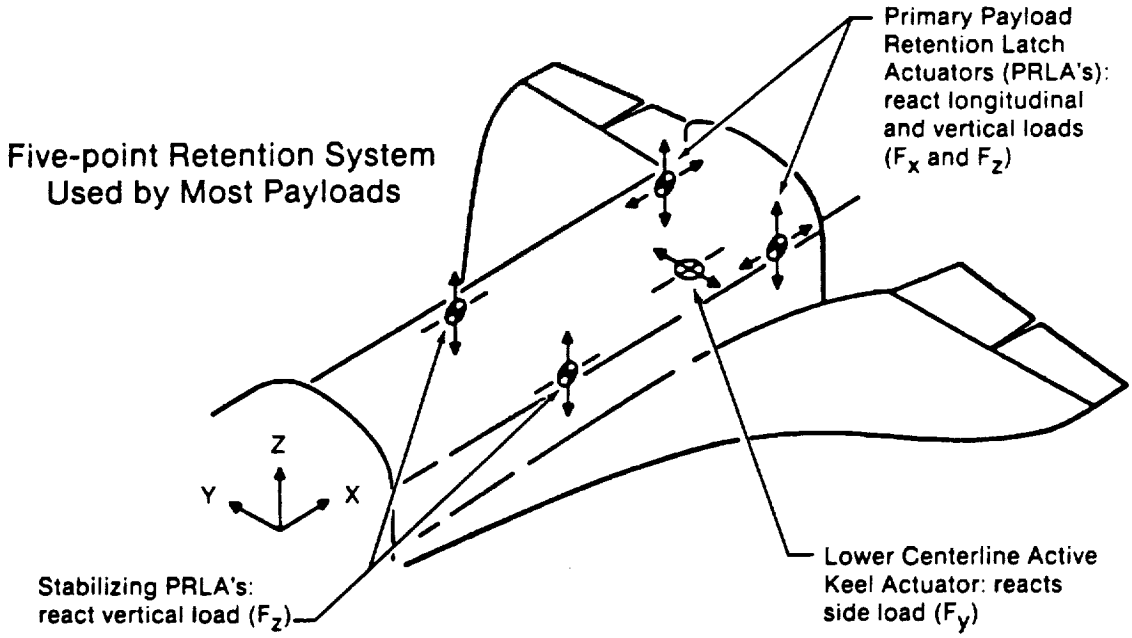
PAYLOAD INTERFACE MECHANISM SOCKET

Technical Information	
Part Number	C95-105
Weight	5.5 lb
Material	Aluminum
Tether Length	6 ft
Quantity Flown	One with the MFR

Dimensional Data	
A	4.06 in.
B	5.56 in.
C	20.875 in.



Payload Retention Systems



OVERVIEW

The Orbiter Payload Retention Systems provide structural attachments for each payload by using four or five attachment points to secure the payload within the Orbiter Cargo Bay during all phases of the Orbiter mission.

OPERATIONAL COMMENTS AND INTERFACE PROVISIONS

The Shuttle Orbiter provides structural support attachment points for either a carrier or a payload along the length of the Cargo Bay. Nondeployable payloads are retained by passive retention devices, and deployable payloads are secured by motor-driven, active retention devices. Payloads are secured in the Orbiter Cargo Bay by means of the Payload Retention System, or they are equipped with their own unique retention systems. The mechanisms are able to function under either one-g or zero-g conditions. Payload berthing or deberthing on-orbit is accomplished by utilizing the Remote Manipulator System.

At the present time paylod retention mechanisms that are capable of supporting a payload of up to 65,000 lb through all phases of flight have been designed, developed, and certified. For weight-saving purposes and handling enhancement, a lightweight latch system is now being designed to accommodate lighter payloads. Intermediate capability latching mechanisms are in the proposal stage. Unique latching systems may be developed by using system components which have already been developed and certified.

STATUS

Structural support attachment points are an integral part of the STS. Latches are flight qualified.

PAYLOAD RETENTION SYSTEMS

CONTACTS

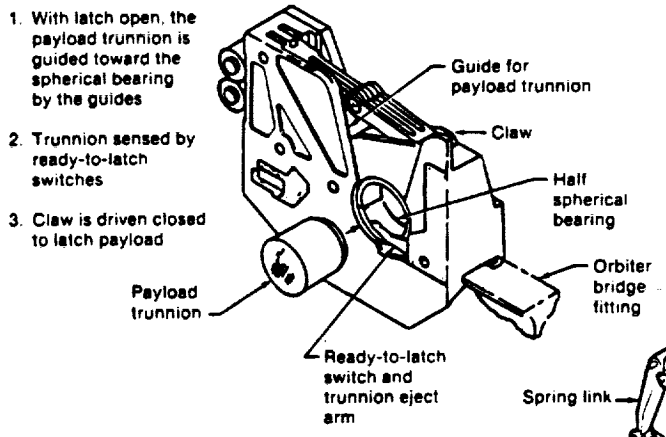
Source: Rockwell International
Operational: D. C. Wade, NASA/JSC/ES, (713)483-2876

REFERENCES

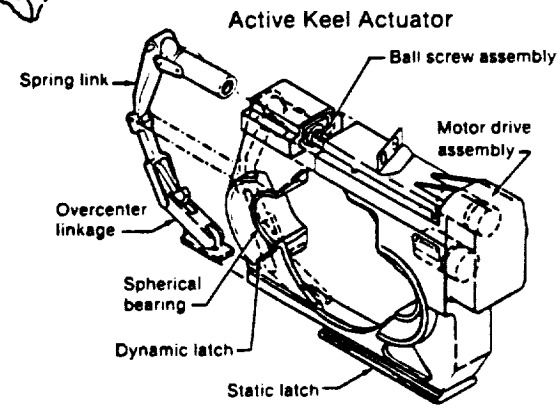
Hardee, J. H.: The Space Shuttle Orbiter Payload Retention System. Rockwell International

Technical Information		
	Longeron latch	Keel latch
Size	Approximately 18 in. by 12 in.	Approximately 19 in. by 14 in.
Weight Standard Lightweight	 113 lb 46 lb	 77 lb 31 lb
Ultimate load in X-Z plane Standard Lightweight	 169,400 lb (radius) 67,600 lb (radius)	 114,200 lb 57,600 lb

PRLA Payload Installation Sequence

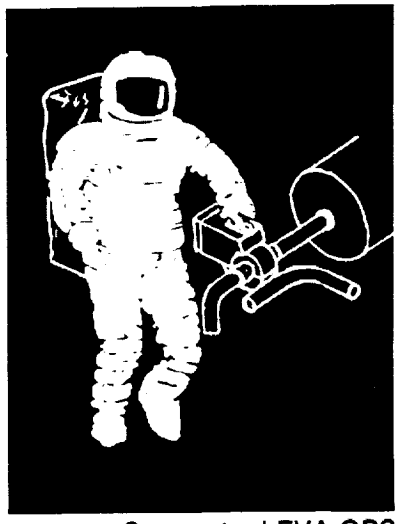


Active Keel Actuator



Portable Electron Beam Welder

Early Engineering Mock-up



Conceptual EVA OPS

OVERVIEW

Portable Electron Beam Welder (PEBW) forms high-integrity, spatterfree butt or lap weld of (dis)similar metals, bending the beam and focusing it onto the target seam via a computer-controlled electromagnetic deflection field. Uses electrical power from battery pack (no umbilical) only, no other consumables. Leakproof welded seams (99.995% success rate) replace heavy, clumsy QD's (in tubes) and adhesives (in flat plate patches) for infinite life. Patented process uses a higher-voltage, lower-current secondary e-beam to scatter x-rays inside welded tubes (collected by CCD's) to digitally inspect welds immediately after formation. Welder highly reliable due to *total lack of critical moving parts*. Gravity-independence, use with rough seams and zero surface preparation make PEBW ideal for leakproof on-orbit joining/inspection.

OPERATIONAL COMMENTS AND INTERFACE PROVISIONS

Packaged PEBW for tubes (above) affixes to tube ends via a clamshell; second tube inserted; welder automatically snugs butt seam; settings chosen (manually or remotely preprogrammed) for depth, power, tube size, beam duration; expert system tracks seam as tubes welded and inspected; 'Weld OK' or 'Defect' annunciated; clamshell opened and welder moved to new position. Anticipate hands-off weld/inspect in 1-5 minutes (exclude tube positioning). I/F with EVA crew or robot.

STATUS

Computer-controlled beam bending, focusing, secondary x-ray inspection technique patented/tested by The Welding Institute. PEBW hard mockup built by WI/Babcock. Prelim. Space Station applications/ops study, interfaces, software & controllers under study by ARRI. Funding required to develop prototype, miniaturize power supply, and test (on-orbit if required, vacuum chamber at least - zero-g does not affect the weld).

PORTABLE ELECTRON BEAM WELDER

CONTACTS

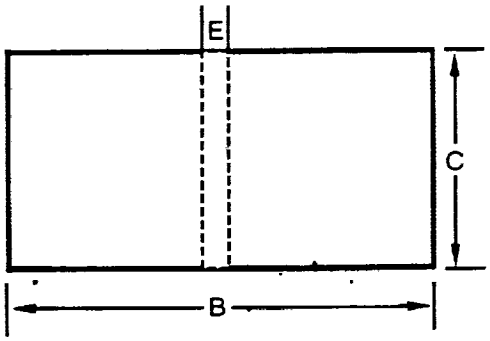
Source: Mr. Martin Peters, Babcock Energy Ltd., Marketing Division., 165 Great Dover Street, London, England SE1 4YA 011-44-1-232-4907
Dr. Alan Sanderson, The Welding Institute, Abington Hall, Cambridge, London, England CB16AL 011-44-223-891162

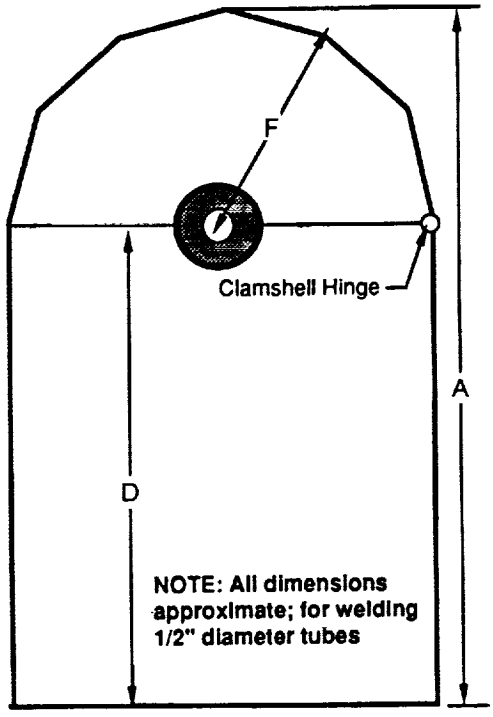
Operational: Mr. Michael L. Drews, Automation & Robotics Research Inst., 7300 Jack Newell Blvd. S., Forth Worth, TX 76118 (817)284-6101

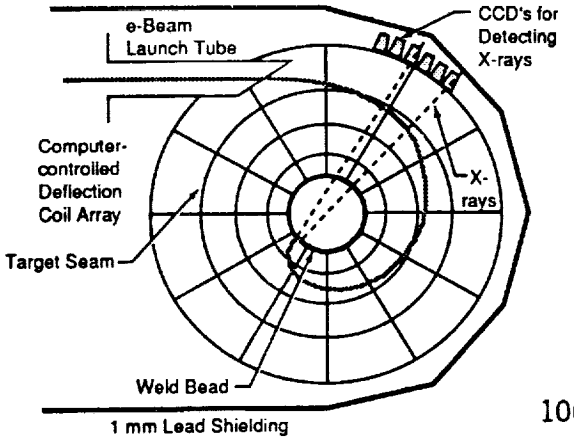
Technical Information	
Part Number	TBD - Proposed
Weight	≤5 kg (12 lbs.) approx.
Power	TBD; dependent on materials list
Status	Eng. mockup, computer models, and prelim. feasibility study complete. X-ray testing in planning stage
Material	Structure - Al pkg. 1 mm Pb foil coils - Specs TBD Beam Gun - TBD
Temp. Range	TBD; dep. on transistor selection
Cooling	Radiative from structure

Interface Details	
Electrical	Power to rechargeable batteries
Mechanical	In Use: Hinged clamshell attaches to tubes; Stowed: TBD
Fluid	None
Electronics	Self-contained microprocessors
Controls	On/Off switch, Status lights, settings panel
Software	Seam tracking, welding, X-ray inspection, reporting to SS S/W
Communications	None if manual; TBD if robotic
Data Rate	TBD if reqd.
Documentation	TBS upon request

Dimensional Data	
A	27.9 cm. (11 in.)
B	15.2 cm. (6.0 in.)
C	7.6 cm. (3.0 in.)
D	20.3 cm. (8.0 in.)
E	1.3 cm. (0.5 in.)
F	7.6 cm. (3.0 in.)







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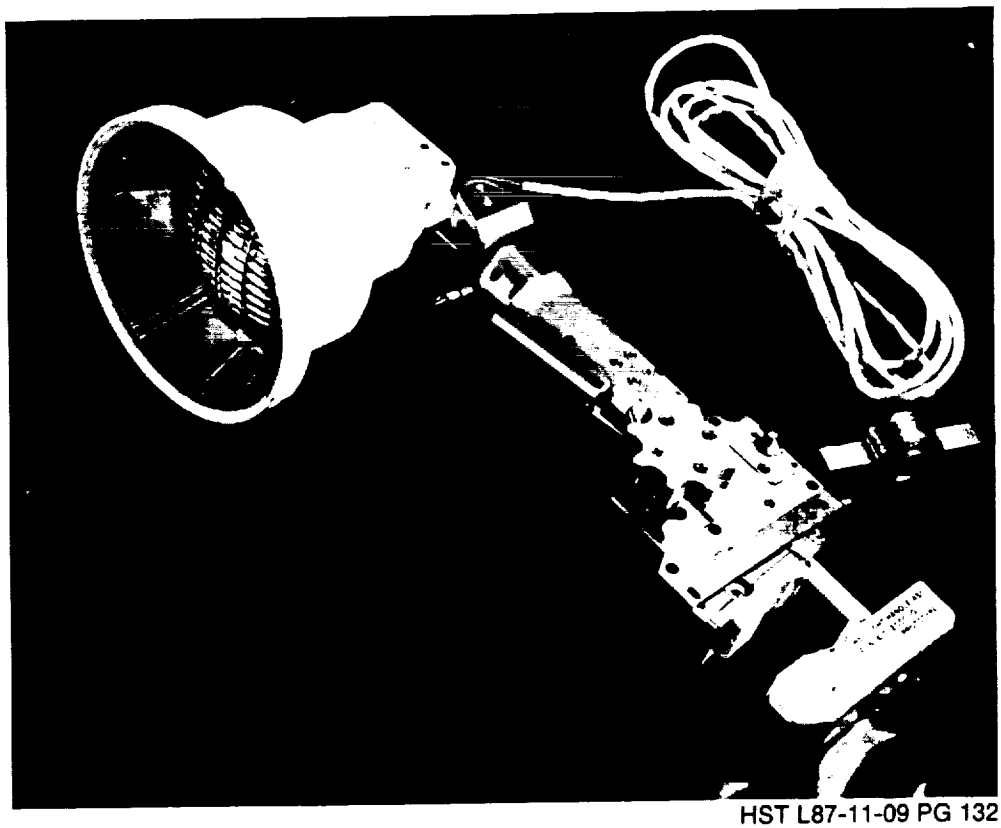
Portable EVA Light



HST L87-11-09 PG 132

OVERVIEW

The HST Portable Floodlight provides portable lighting during extravehicular activity. It provides a minimum of 30 foot candles at a distance of 10 feet and has an electronic intensity control which can be preset at assembly. It can also be operated by EVA astronauts.

OPERATIONAL COMMENTS AND INTERFACE PROVISIONS

Requires 50 watts at 28 volts D.C. Has 8 foot power cord. Handle clamping ranges from 0.250 to 0.375 inches. Seal beam life of 400 hours.

STATUS

Ready for STS flight use.

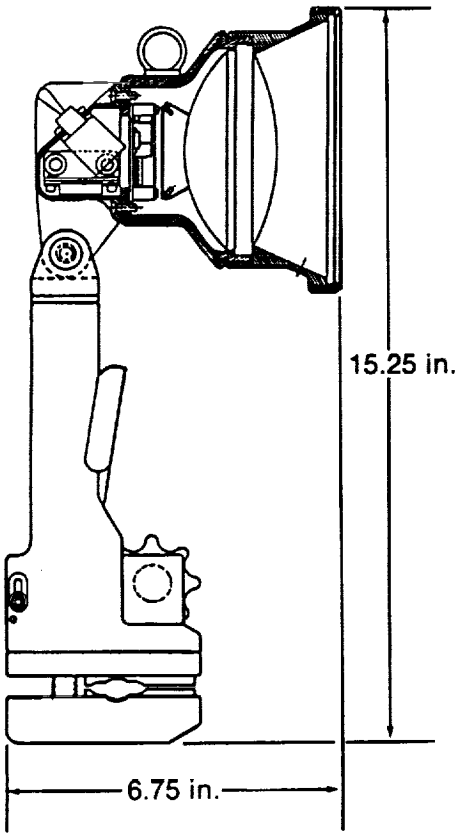
CONTACTS

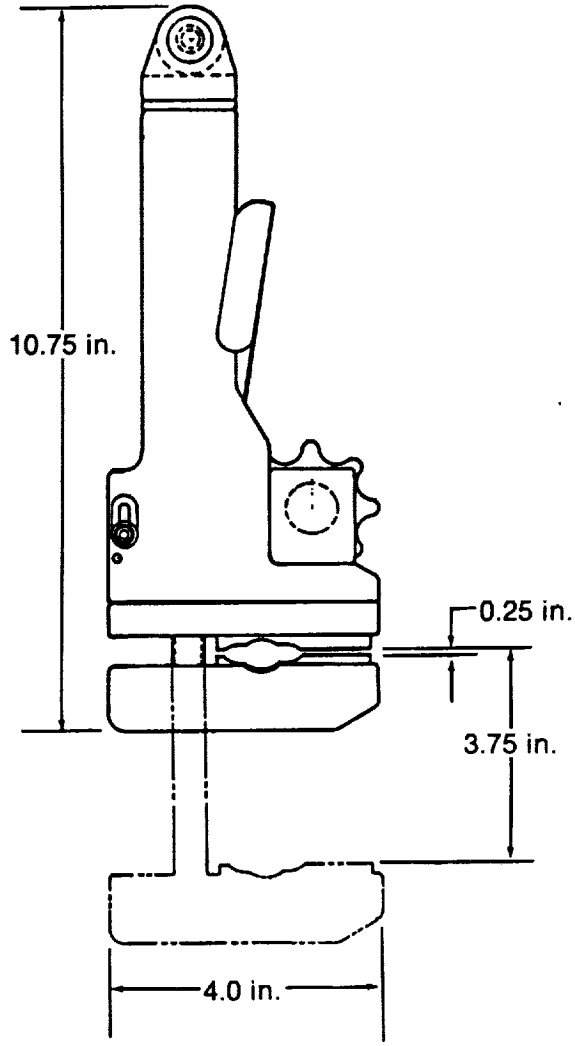
Source: Marshall Space Flight Center, Huntsville, AL 35812
Operational: J. R. Turner, NASA/MSFC PS-01, (205)544-0617

PORTABLE EVA LIGHT (HST)

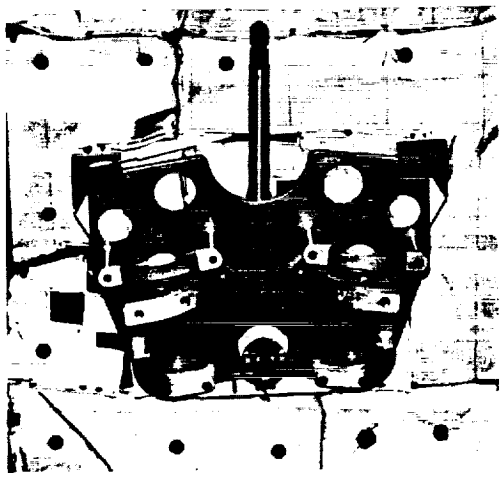
Technical Information	
Part Number	16101-10061-01
Weight	6.5 lbs.
Power	47.3
Temperature Range	-67° F to 257° F

Interface Details	
Electrical	28 V DC, external via power cord
Plug Part	# 860547765-8P (GFE)





Portable Foot Restraint



S84-42686

OVERVIEW

The Portable Foot Restraint (PFR) is a working platform which restrains the crewmember during the performance of EVA tasks. The platform consists of a system of toe guides and heel clips which interface with the EMU boots. A two-axis (roll and pitch) gimbal system with lock knobs is provided for adjustment and positioning. A probe enables the PFR assembly to interface with the worksite at the PFR socket, where yaw adjustment is available.

OPERATIONAL COMMENTS AND INTERFACE PROVISIONS

The PFR was originally designed to provide Space Shuttle EVA crewmembers with a contingency restraint system for performing EVA work tasks and door latch repairs on or about the forward and aft bulkhead and along the centerline door latches of the payload bay. As EVA operations increased in frequency, new applications for its use were identified and improvements were made in the design to minimize set-up and adjustment times as well as to increase the operational work load limits from 25 to 100 pounds. Several configurations of the PFR exist, varying in mounting socket design and probe lengths and are capable of attachment to a variety of work surfaces. Spring-loaded lock knobs have also been incorporated into the later configurations to prevent inadvertent unlocking of the gimbal system. One PFR platform is part of the normally manifested STS equipment.

STATUS

Flight qualified. Flown on specific STS flights.

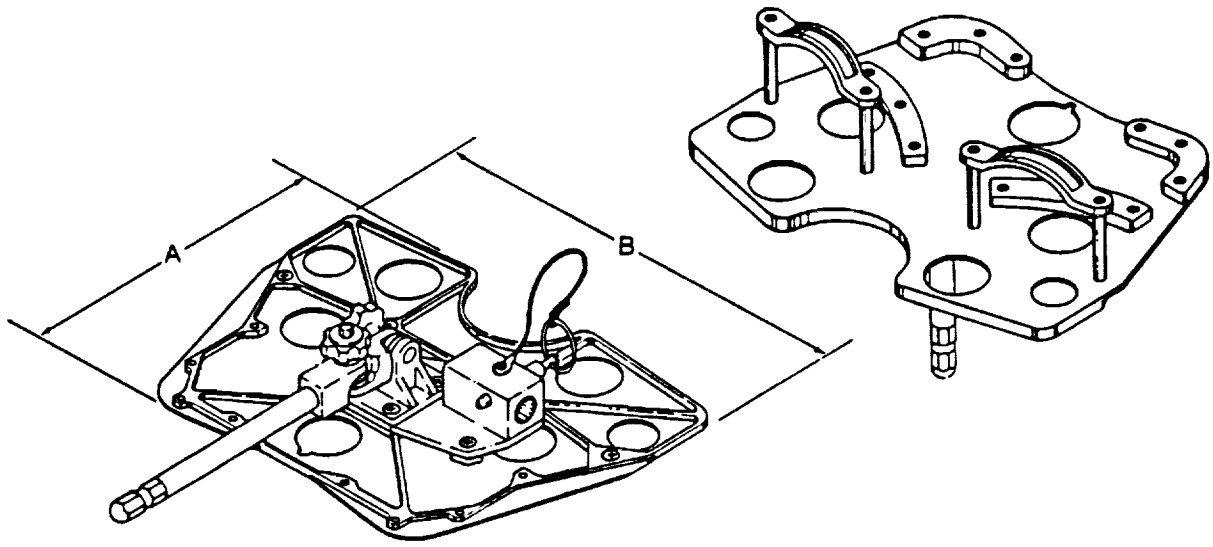
CONTACTS

Source: M. Withey, ILC Space Systems, (713)488-9080
Operational: R. C. Trevino, NASA/JSC/DF, (713)483-2597

PORTABLE FOOT RESTRAINT

Technical Information	
Part Number	10159-10034-01, -02
Weight	8.4 lb
Material	Aluminum alloy
Input Load	10176 configuration - 100 lb, any direction 10155 configuration - 25 lb, any direction
Quantity Flown	One
Stowage	Orbiter forward bulkhead

Dimensional Data	
A	15.94 in.
B	20.5 in.



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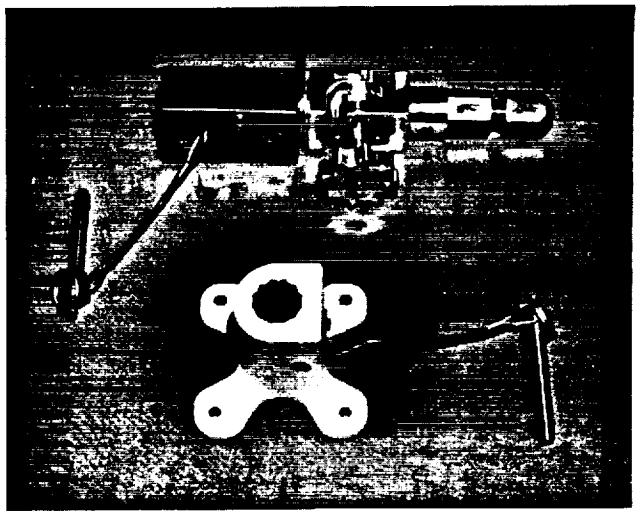
Portable Foot Restraint Socket



S84-25783

OVERVIEW

The Portable Foot Restraint (PFR) Socket, also called the 12-point socket, secures the PFR extension arm to a stationary location. There are three types of PFR sockets. Two types have only one socket position; the third has separate socket positions for stowage and use. Each type has a 12-point polygon-shaped receptacle into which the hex-shaped probe of a PFR is inserted and secured by self-tethering quick-release pins.

OPERATIONAL COMMENTS AND INTERFACE PROVISIONS

The PFR socket used on the Solar Maximum satellite (Solar Max) repair mission (10172-20433) is made of stainless steel and has only one PFR receptacle. The PFR socket 10174-20019, made of aluminum, has two PFR receptacles in which the PFR extension arm may be secured: one for launch, the other for use. The PFR socket 10176-20648 is similar to the Solar Max socket except that is is made of aluminum and has a thicker base to withstand greater loads. The PFR can be mounted to the socket for launch and EVA use. A tether pip pin is incorporated to lock the socket to the PFR.

STATUS

Flight qualified. Flown on specific STS flights.

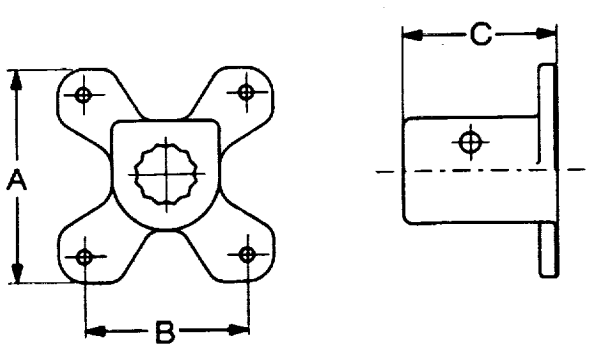
CONTACTS

Source: M. Withey, ILC Space Systems, (713)488-9080
Operational: R. C. Trevino, NASA/JSC/DF, (713)483-2597

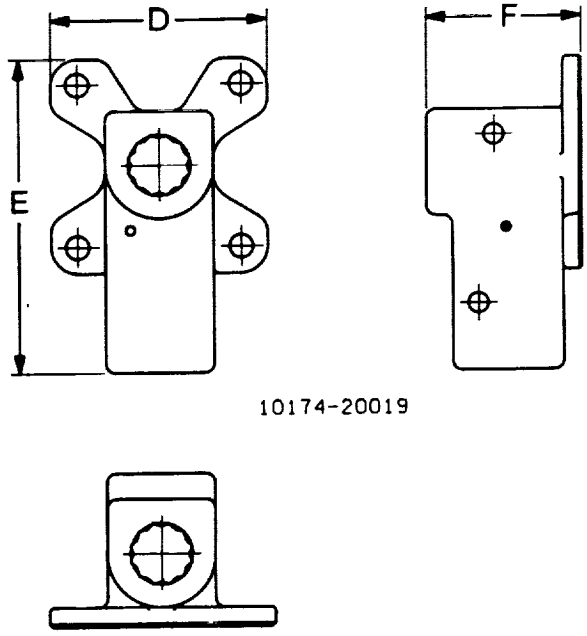
PORTABLE FOOT RESTRAINT SOCKET

Technical Information	
Part Number	10172-20433 10174-20019 10176-20648
Material/Weight	10172-20433 - stainless steel/6 lb 10174-20019 - aluminum/2.813 lb 10176-20648 - aluminum/2.0 lb

Dimensional Data	
A	4.000 in.
B	3.0 in.
C	2.88 in.
D	4.000 in.
E	5.88 in.
F	2.88 in.



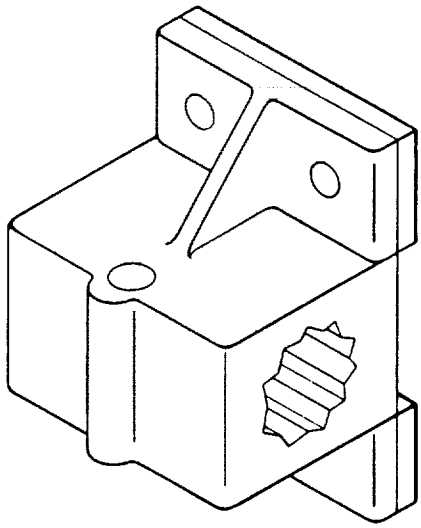
10172-20433
10176-20648



10174-20019

204660109. ART. 3

PFR Socket (HST)



OVERVIEW

The Hubble Space Telescope (HST) Portable Foot Restraint (PFR) socket is a 12-point receptacle which mates with the HST PFR. It provides a stable foot restraint for an EVA crewmember performing space telescope maintenance or repair. The PFR socket receptacles are located at various work stations along the shell of the space telescope.

OPERATIONAL COMMENTS AND INTERFACE PROVISIONS

The PFR socket is equipped with a pip pin hole. When the HST PFR is inserted into the socket, a pip pin attached to the PFR is inserted to prevent the PFR from coming out of the socket. The PFR socket structure has four mounting holes 0.287 inch in diameter for mounting. Because of the large number of PFR sockets on the HST, each socket does not have an attached pip pin but relies on a pip pin from the PFR.

STATUS

Flight qualified. Will be flown on the STS/HST flights.

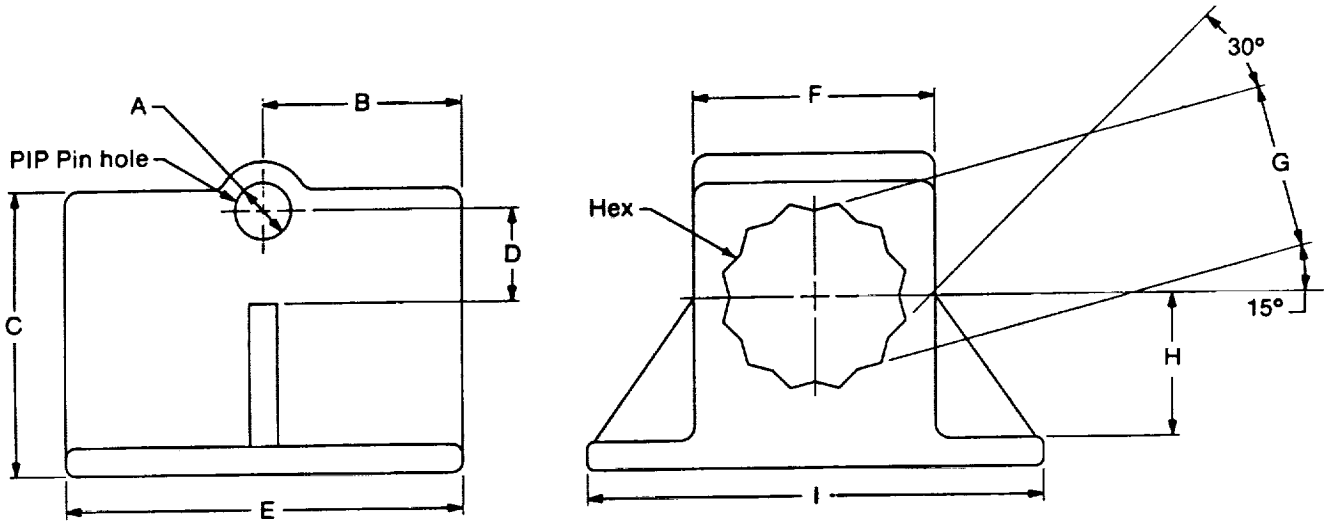
CONTACTS

Source: LMSC, HST Contracts Office, (408)742-5505
Operational: K. A. Havens, NASA/JSC/DF, (713)483-2569

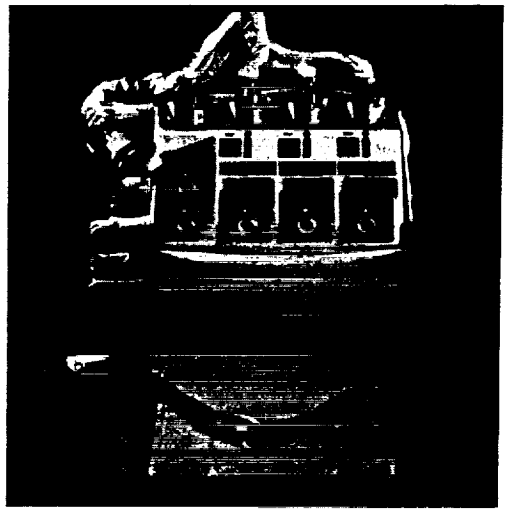
PFR SOCKET (HST)

Technical Information	
Part Number	4173704
Weight	0.78 lb
Material	Aluminum alloy
Construction	Mounting holes - 0.287-in. dia Pip pin - 0.375-in. dia

Dimensional Data	
A	0.375 in.
B	1.250 in.
C	2.00 in.
D	0.544 in.
E	2.50 in.
F	1.625 in.
G	1.0055 in.
H	1.250 in.
I	3.62 in.



Power Package, EVA



S85-31369

OVERVIEW

The EVA Power Package (EPP) is a portable general purpose power supply. It is currently configured as a contingency power source for payload assist module D (PAM-D) sunshield operations in the event of an Orbiter power failure.

OPERATIONAL COMMENTS AND INTERFACE PROVISIONS

The EPP can provide up to 10 amp-hours, using an EMU battery, with controls for four independent circuits, main power, and self test to confirm operation of the system under load. One or any combination of the four circuits provides 6.0 amps of continuous power, 8.0 amps surge capability at 28.0 ± 2.0 volts dc, and 10-amp circuit-interrupt protection.

Controls include a system on/off switch and four output control switches. There are four 19-pin output/monitoring connectors and five lift-to-lock, three-position toggle switches. Control circuit labels can be replaced for different mission applications. The EPP has a handle grip and two adjustable tethers and passive thermal protection for a 6-hour EVA.

STATUS

Flight qualified. Flown on specific STS flights.

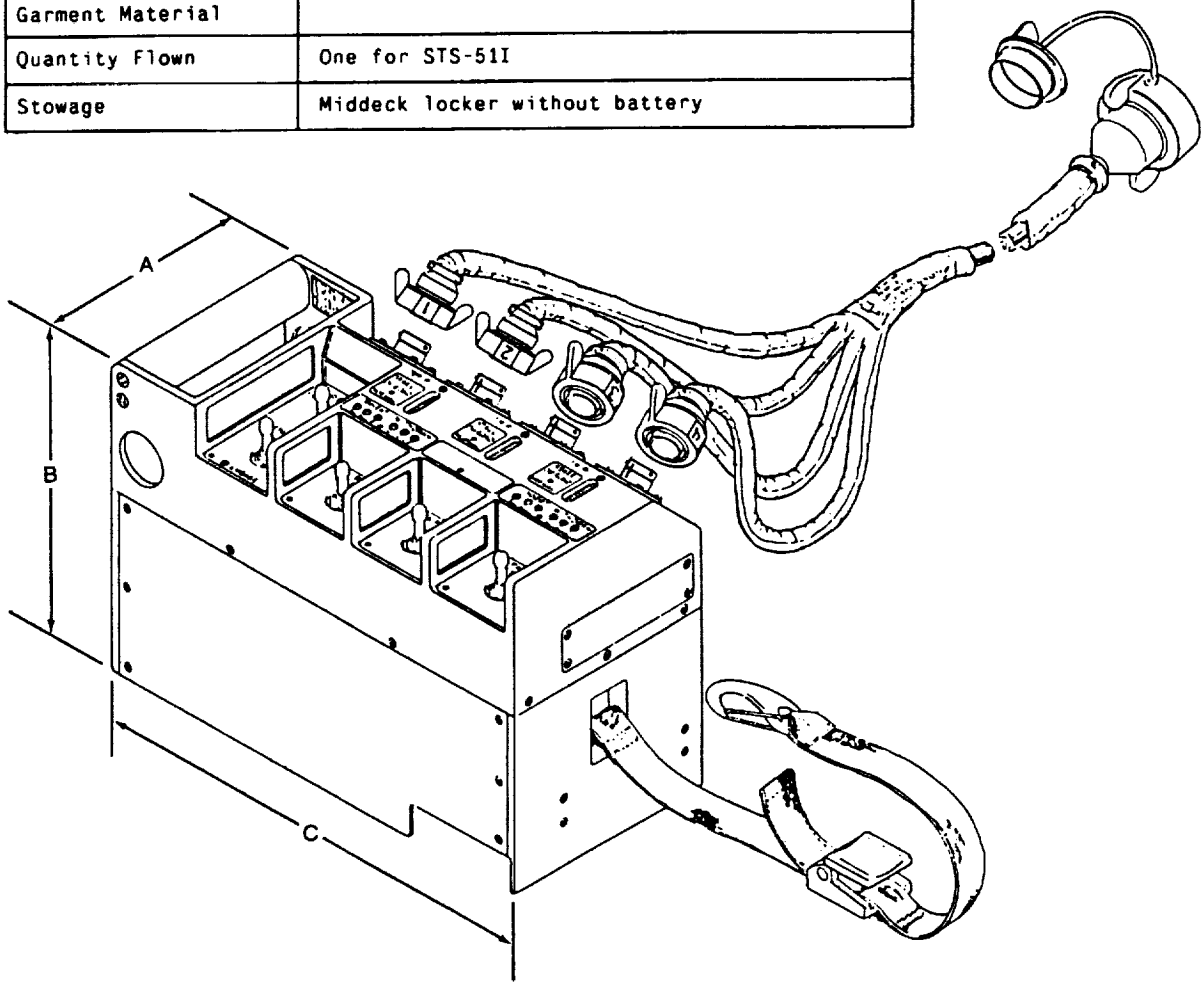
CONTACTS

Source: M. Withey, ILC Space Systems, (713)488-9080
Operational: R. C. Trevino, NASA/JSC/DF, (713)483-2597

POWER PACKAGE, EVA

Technical Information	
Part Number	10175-10075
Weight	37 lb
Continuous Output Capacity	6 A
Capacity	10 A-hr
Voltage	28 ± 2 V dc
Interrupt settings	3.5, 4.5, 7.5 A
Max Battery Temp for 12 min	115° F
Max Temp for 1 hr 10 min Operation	160° F
Thermal Protection Garment Material	Ortho, Teflon fabrics, aluminized maylar, and polyester scrim
Quantity Flown	One for STS-51I
Stowage	Middeck locker without battery

Dimensional Data	
A	6.3 in.
B	9.4 in.
C	13.0 in.



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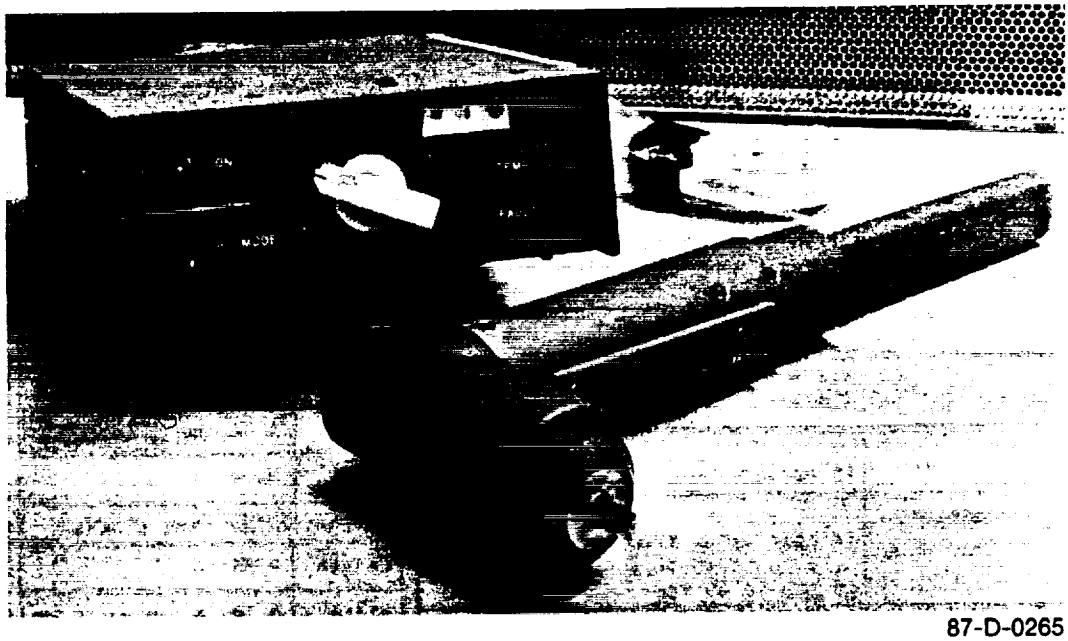
Power Ratchet Tool



87-D-0265

OVERVIEW

The Power Ratchet Tool (PRT) is a self-contained, power-driven, 3/8 inch drive ratchet tool for extravehicular use.

OPERATIONAL COMMENTS AND INTERFACE PROVISIONS

The PRT is battery powered and is controlled by a dedicated electronic controller, which is designed to be carried on the crewmember's mini-workstation. Fourteen discrete combinations of torque, turn, and speed may be programmed prior to the mission. The crewmember controls these parameters of the tool by a switch mounted on the controller. A trigger, located on the handle, is the start/stop control for the tool (not shown in above picture). The tool may also be used in a manual mode similar to a non-powered ratchet wrench. The direction of the ratcheting action may be changed by the crewmember using an external switching ring surrounding the gearhead/ratchet assembly. The silver-zinc battery module is replaceable during an extravehicular activity (EVA).

STATUS

A. Flight unit:
   - First version - undergoing integration
   - Second version - undergoing development

B. Prototype unit:
   - Available for one-gravity dry-land and KC-135 aircraft training and demonstration

C. Underwater training unit:
   - Undergoing development

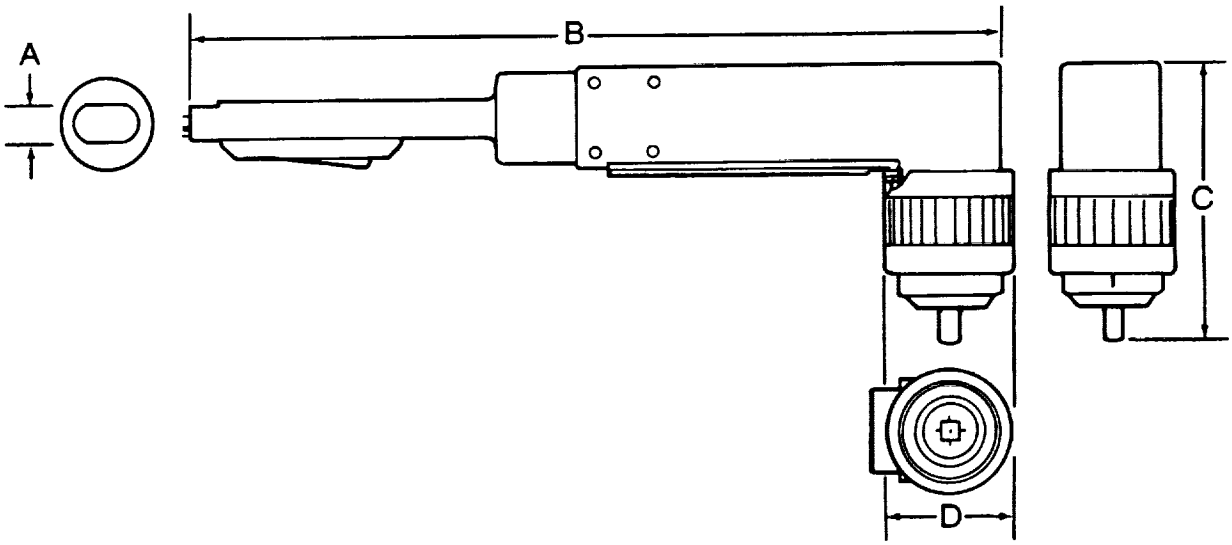
POWER RATCHET TOOL

CONTACTS

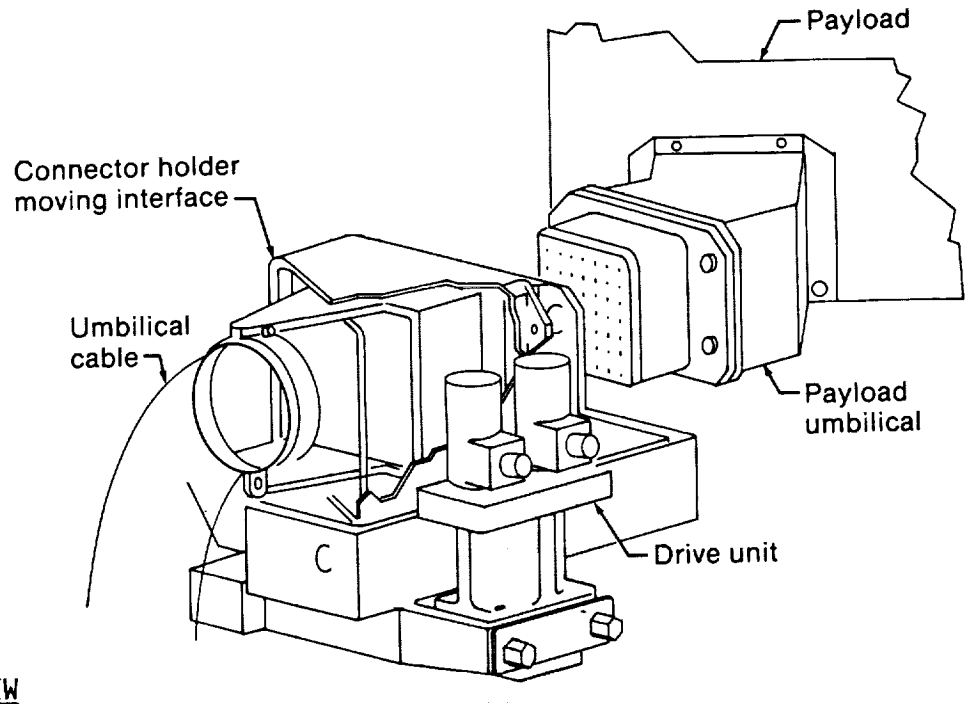
Source: R. Lewis or K. Rosette, NASA/GSFC, Code 408,
(301)286-2060 or (301)286-7201
Operational: Capt. B. McCandless II, NASA/CB, (713)483-2421

Technical Information	
Part Number	Not available
Weight Ratchet Assembly Controller Battery Module	 8.5 lbs 4.0 lbs 3.0 lbs
Operating Torque Maximum Manual	 75 ft-lb
Programmable Parameters Torque Turns Speed	 Integer value from 1 to 25 ft-lb Zero to Continuous 10 rpm to 50 rpm
Power Input	28 V dc; silver-zinc, EVA exchangeable

Dimensional Data	
Wrench portion (as shown)	
A	0.75 in.
B	15.9 in.
C	5.45 in.
D	25.0 in.
Controller (not shown)	
Length	9.65 in.
Width	8.20 in.
Height	2.97 in.



Remote Electrical Umbilical



OVERVIEW

The Remote Electrical Umbilical (REU) was initially designed for use on the NASA/GSFC Flight Support System (FSS) as an umbilical between the FSS and spacecraft.

OPERATIONAL COMMENTS AND INTERFACE PROVISIONS

Provides a 4 inch stroke with 400 pounds force utilizing dual redundant motors. Mechanism is locked against backdrive when power is removed and is redundant from the motor to output shaft. EVA backup is provided for mate/de-mate.

Utilizes G&H Model 882-series connector with engagement angles of ± 10° with ±0.12 inch misalignment.

STATUS

Has been flown on a number of STS missions. Six umbilicals fabricated and delivered to NASA/GSFC

CONTACTS

Source: Rockwell International, 12214 Lakewood Blvd., Downey, CA 90241
Operational: C. W. Anderson, RI, (213)922-5095
R. L. Gasteiger, (213)922-5339

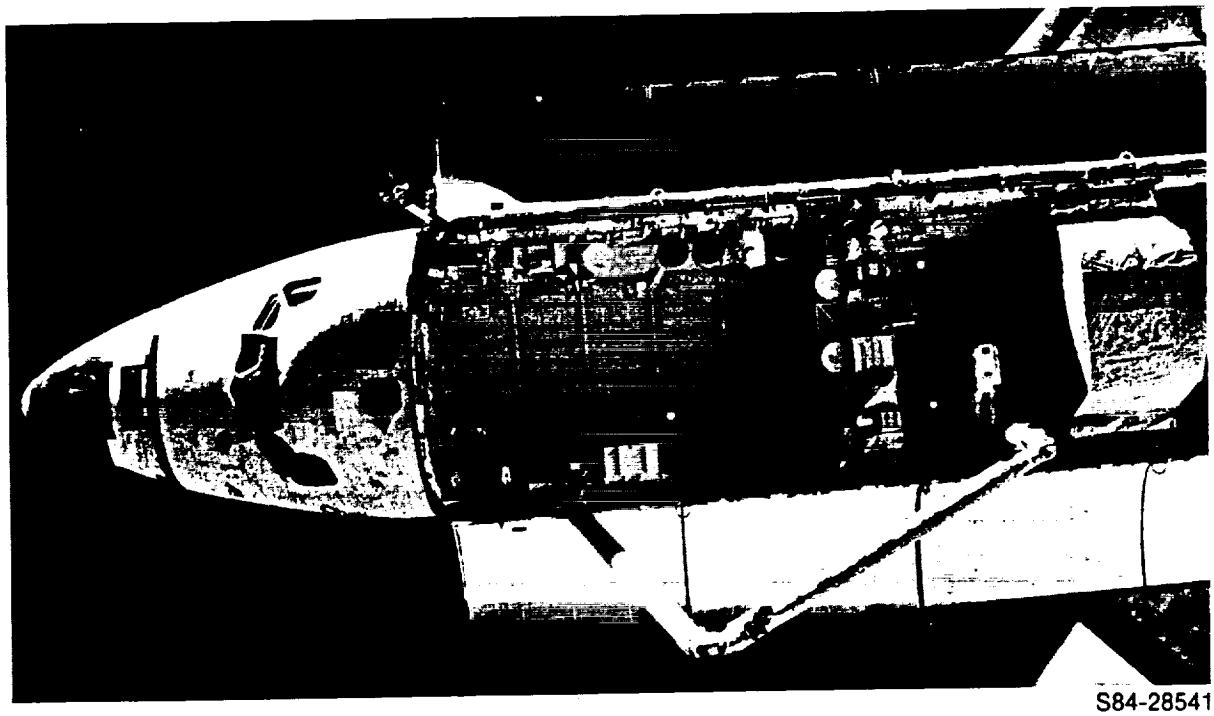
REMOTELY ELECTRICAL UMBILICAL

Technical Information	
Weight	20 pounds
Power Req	115V ac, 400 Hz, 3 phase
Temp Range	N/A
Cooling	N/A
Status	Flight Qualified

Interface Details	
Electrical	See below
Mechanical	N/A

Electrical Interface Details		
Contact Type	Quantity	
	ARRNG. #1	ARRNG. #2
Size 8	8	26
Size 16	50 min 60 max	80
Coax (RG-393/U)	6	0
Coax (RG-142B/U)	6	2

Remote Manipulator System



S84-28541

OVERVIEW

The Remote Manipulator System (RMS) is a mechanical arm which augments the Shuttle systems in performing the deployment and/or retrieval of a payload. In addition, the RMS may be used to perform other tasks in support of satellite servicing or to assist in extravehicular activities.

OPERATIONAL COMMENTS AND INTERFACE PROVISIONS

The manipulator arm consists of four joints connected by structural members to a payload-capturing device called an end effector. The movement of the arm is controlled by an operator using a display and control panel and two three-degree-of-freedom hand controllers. The operator also has visual access through the windows in the Aft Flight Deck. The manipulator arm is anthropomorphic by design, comprising shoulder pitch, shoulder yaw, and elbow pitch joints (mainly providing end-point translation) plus wrist pitch, yaw, and roll joints (providing rotation of the end effector). The RMS is stowed outside of the Cargo Bay envelope on the port longeron and is charged to Orbiter weight.

STATUS

The RMS is an integral part of the STS.

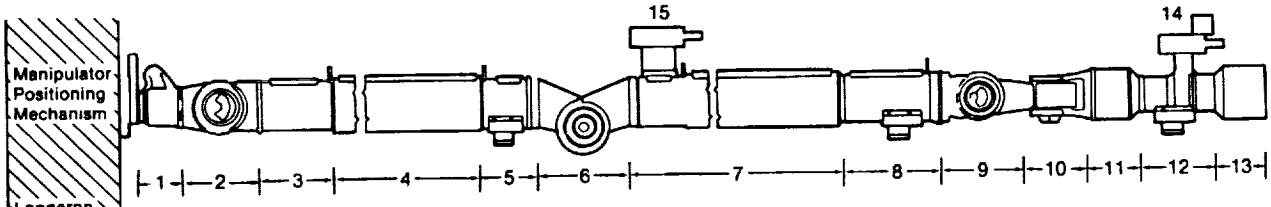
CONTACTS

Source: SPAR, Canada (416)745-9680 Telex: 065-27360
Operational: R. Zaguli, NASA/JSC/DF441, (713)483-0887

REFERENCES

Level II Program Definition and Requirements, Vol. 14, Space Shuttle System Payload Accommodations, Rev. G, Attachment 1. JSC-07700, ICD-2-19001, May 1983.
RMS Design Definition Report, Issue E. SPAR-R.776.
Shuttle Orbiter/Cargo Standard Interfaces. ICD-2-19001.

Technical Information	
Length	50 ft
Weight	905 lb (add 28 lb for elbow camera)
Positioning Accuracy (within reach envelope)	± 2 in. ± 1°
Payload Release	± 5° attitude <0.015° per sec relative delta v Approx 0.1 to 1.0 ft/sec delta v
Design Limit Load	Torsional moment about longitudinal axis of end effector: 750 ft-lb Bending moment to end effector: 1200 ft-lb Shear force associated with bending moment: 50 lb
Payload Characteristics	Maximum size: 15 ft diameter by 60 ft long cylinder Maximum nominal payload weight: 32,000 lb Maximum contingent payload weight: 65,000 lb

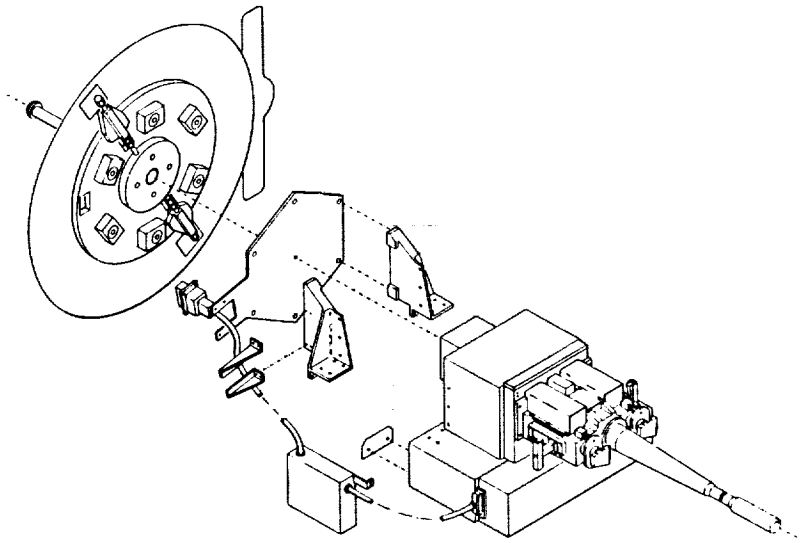


Components

1. Shoulder yaw joint
2. Shoulder pitch
3. Shoulder elect. comp
4. Upper arm boom
5. Elbow elect. comp
6. Elbow joint
7. Lower arm boom
8. Wrist fwd elect. comp
9. Wrist pitch joint
10. Wrist yaw joint
11. Wrist aft elect. comp
12. Wrist roll
13. Standard end effector
14. CCTV Camera and viewing light - wrist location
15. CCTV Camera with pan/tilt unit - elbow location

(Figure shows shoulder pitch joint rotated through 90° from stowed position)

Remote Manipulator System Module Servicing Tool



OVERVIEW

The Remote Manipulator System Module Servicing Tool (RMS MST) is a device to permit remote on-orbit exchange of Orbital Replacement Units (ORUs) when it is coupled to the RMS. It develops high torques, up to 160 ft-lbs, with provision for torque takeout and transporting of multimission modular spacecraft (MMS) and other compatible ORUs. The tool is controlled and operated from the Space Shuttle Aft Flight Deck. The RMS MST is modelled from an extravehicular activity (EVA) astronaut operable tool used for the same purpose (see "Module Servicing Tool").

OPERATIONAL COMMENTS AND INTERFACE PROVISIONS

The RMS MST retains an internal MMU battery to power its bolt and latch motors. Remote control can be performed either by manual or automated modes. Pickup and restowing of the tool is performed by use of the RMS grapple to an electrical grapple fixture at the rear of the tool. The electrical umbilical accommodates command and telemetry functions.

STATUS

Electrical and mechanical design modifications to a prototype EVA MST are underway which will permit remote control of the tool. Johnson Space Center is defining the interface control document and developing a flight-releasable electrical grapple fixture for general applications. A companion holster, to be used for mounting the RMS MST on the MMS Flight Support System or other structural cradle, is also undergoing development.

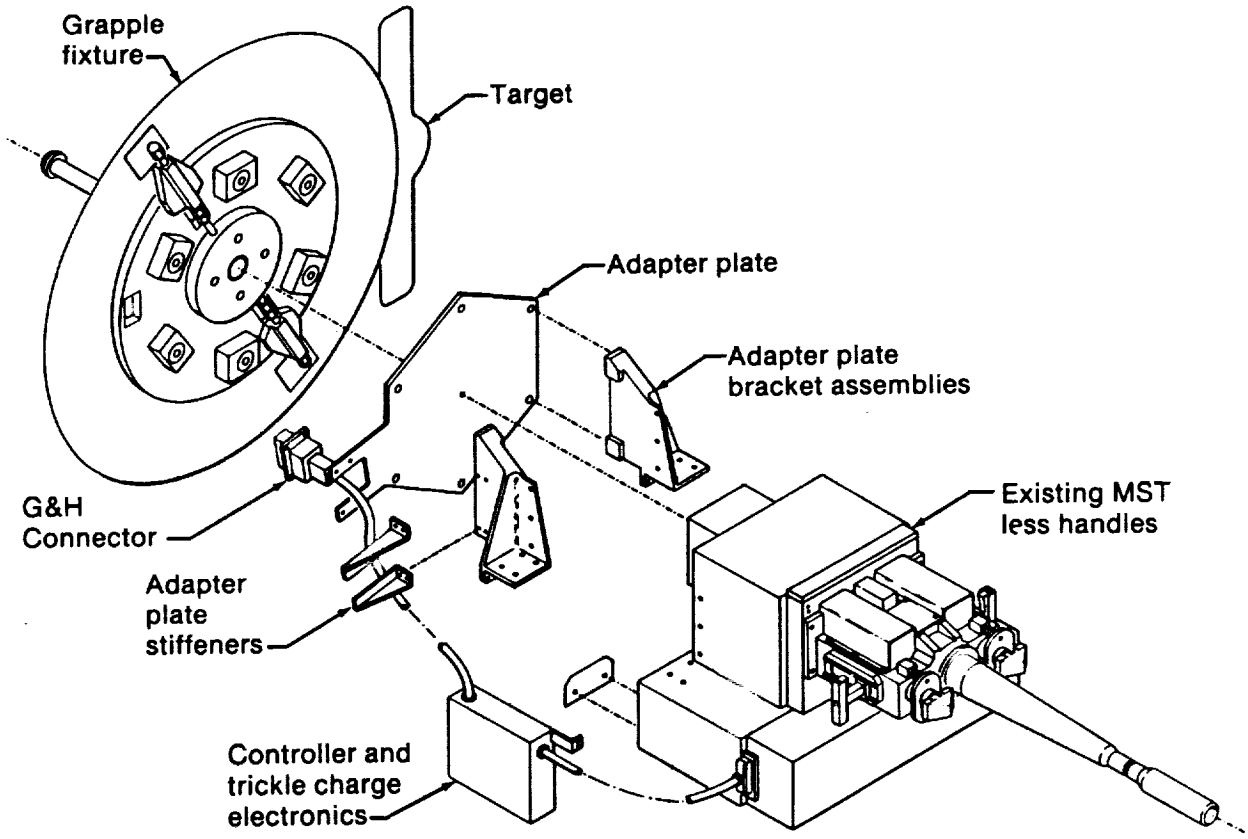
CONTACTS

Source: R. E. Davis, NASA/GSFC SSP/Code 408.0, (301)286-2260
Operational: R. E. Davis, NASA/GSFC SSP/Code 408.0, (301)286-2260

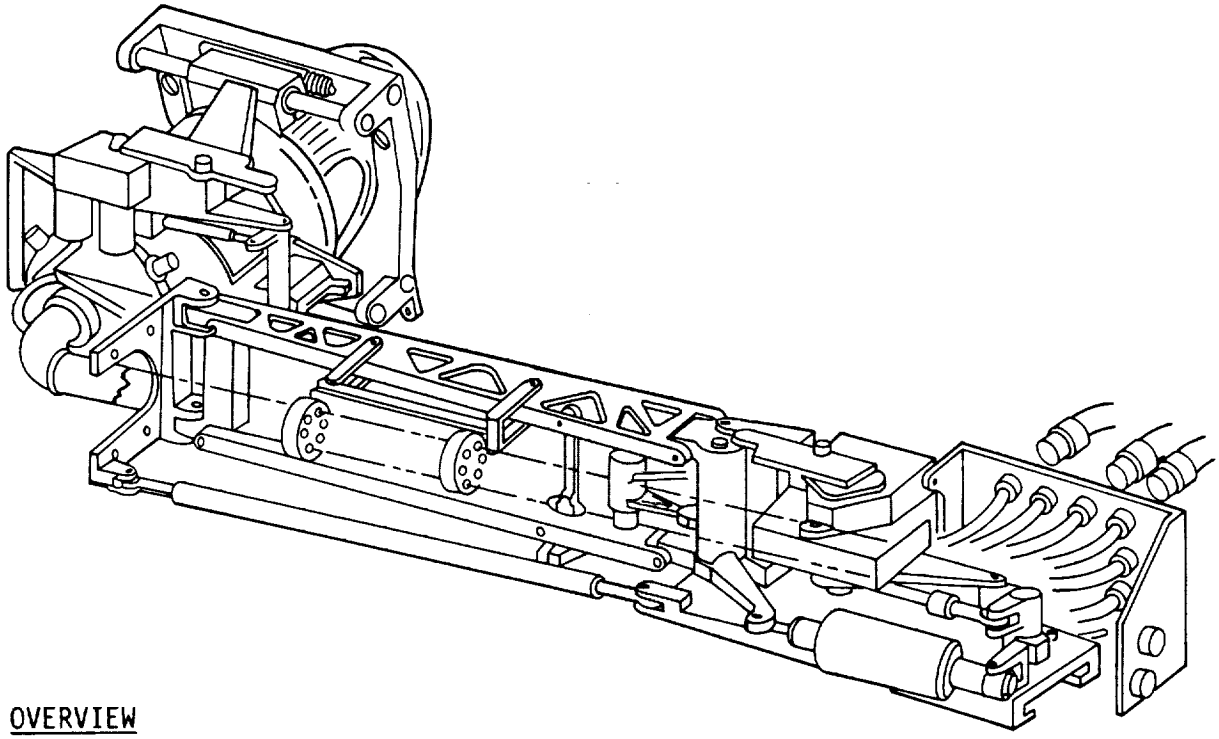
REMOTE MANIPULATOR SYSTEM MODULE SERVICING TOOL

Technical Information	
Part Number	TBS
Weight	Approx. 90 lbs.
Power	Integral 17 VDC MMU battery/28 VDC contr/TML
Status	Phase B design MODS and phase D EVA MST hardware
Materials	Structure - aluminum
Temperature Range	-50 to +100 deg. F; degr -100 to +250 deg. F
Pressure	Min. 10^{-10} Torr
Operations	Intermittant over 4 yrs with minor servicing

Interface Details	
Interface Device	RMS Lt-Wt Flt releasable electrical grapple fixture
Precapture Misalignment Limits	4" pitch/yaw radius 4" axial +/- 15 deg all attitudes
Electrical Connector	51-contact modified sub-miniature "D" connector
Cable Type	Interconnections via RMS wiring to Aft Flt Deck
Type OPNS	Mission specialist contrs RMS and MST from Aft Flt deck controllers/panels
Contacts Assignment	Per JSC document TBS



Remotely Operated Electrical Umbilical



OVERVIEW

The Remotely Operated Electrical Umbilical (ROEU) provides a remateable electrical disconnect that can accommodate a full 1/4 SMCH (R.F, ML, HO and Power).

OPERATIONAL COMMENTS AND INTERFACE PROVISIONS

Mounts on port or starboard bridge rail with a maximum 1.5 inch intrusion into the 180 inch payload envelope. Provides self alignment of orbiter and payload portions of the disconnect and accommodates orbiter/payload relative motions. Essentially zero load imparted to payload during mate/de-mate operations.

Two units (1 port and 1 starboard) to be fabricated, flight qualified and delivered to NASA.

STATUS

Flight units to be delivered in 1988.

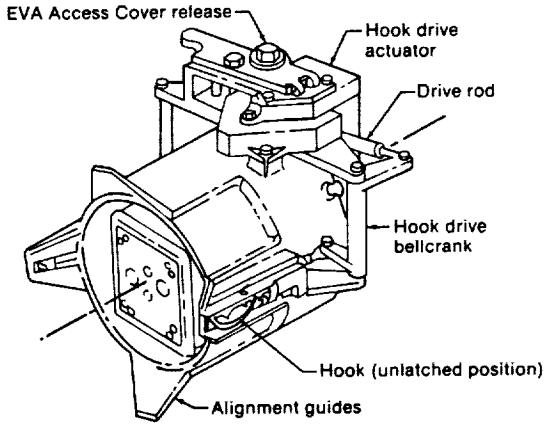
CONTACTS

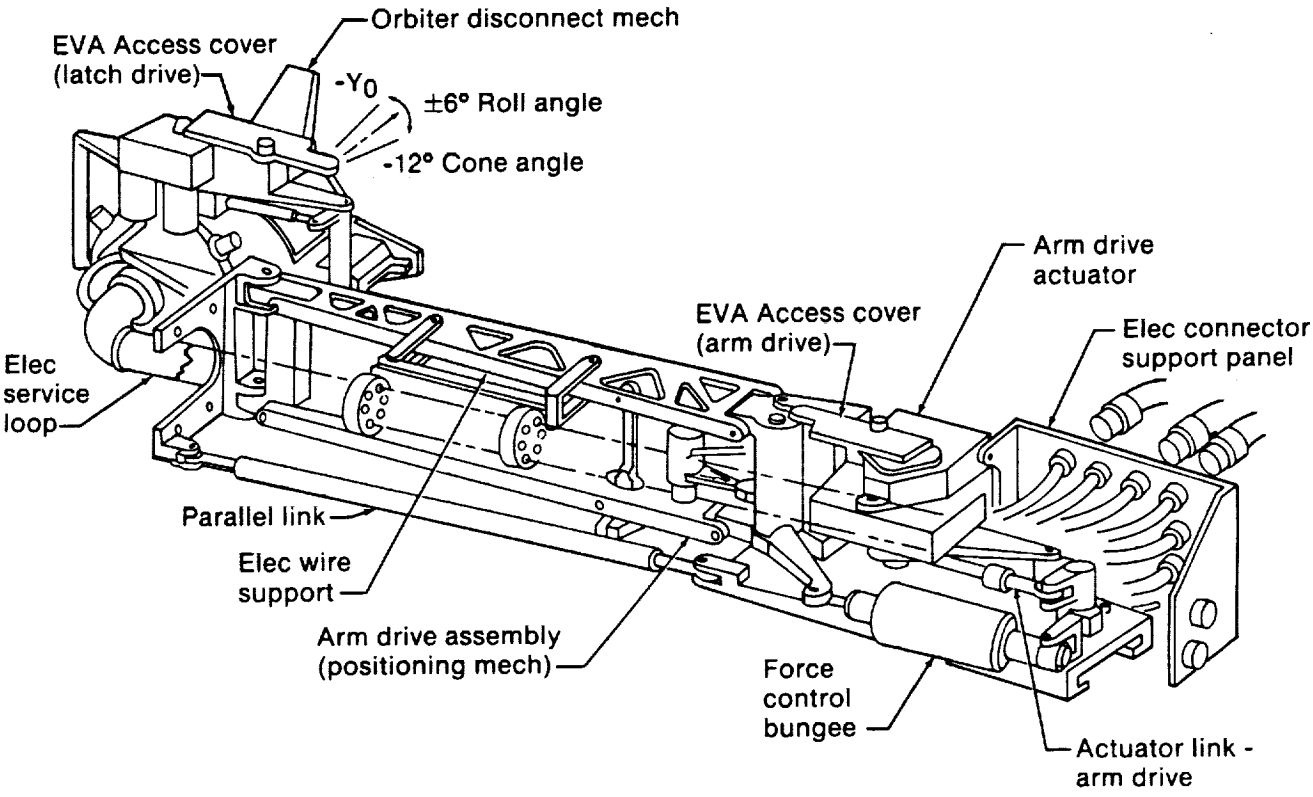
Source: Rockwell International, 12214 Lakewood Blvd., Downey, CA 90241
Operational: C. W. Anderson, RI, (213)922-5095
R. L. Gasteiger, (213)922-5339

REMOTELY OPERATED ELECTRICAL UMBILICAL

Technical Information	
Weight	65 pounds
Power Req	28V dc
Temp Range	100° F to + 250° F
Cooling	N/A
Material	Aluminum
Status	In final manufacture 6/87

Interface Details	
Electrical	See Design Requirements Doc. STS-85-0121
Mechanical	See Design Requirements Doc. STS-85-0121
Data Rate	N/A
Documentation	Design Requirements Doc. STS-85-0121





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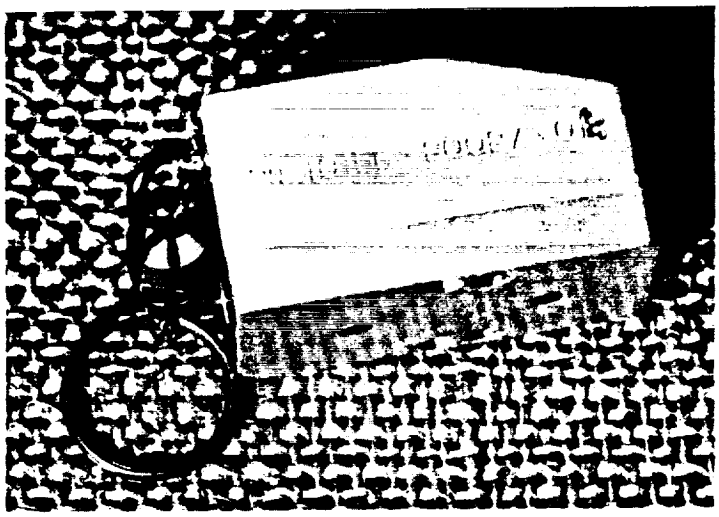
Retractable Tether



S85-39485

OVERVIEW

Retractable tethers are used to restrain tools and small equipment stowed on tool boards and tool caddies for use during EVA. Tethers consist of a take-up reel enclosed in a housing, a 3-foot or 6-foot Kevlar tether line, and a swivel hook or hooks to secure tools and equipment. The 6-foot tether design incorporates a velocity limiting feature.

OPERATIONAL COMMENTS AND INTERFACE PROVISIONS

The retractable tether extends and retracts smoothly, with no more than 0.6 pounds of retracting force. A French hook is sometimes fixed to the swivel hook to permit release of a tool from the retractable tether.

STATUS

Flight qualified. Flown on all STS flights.

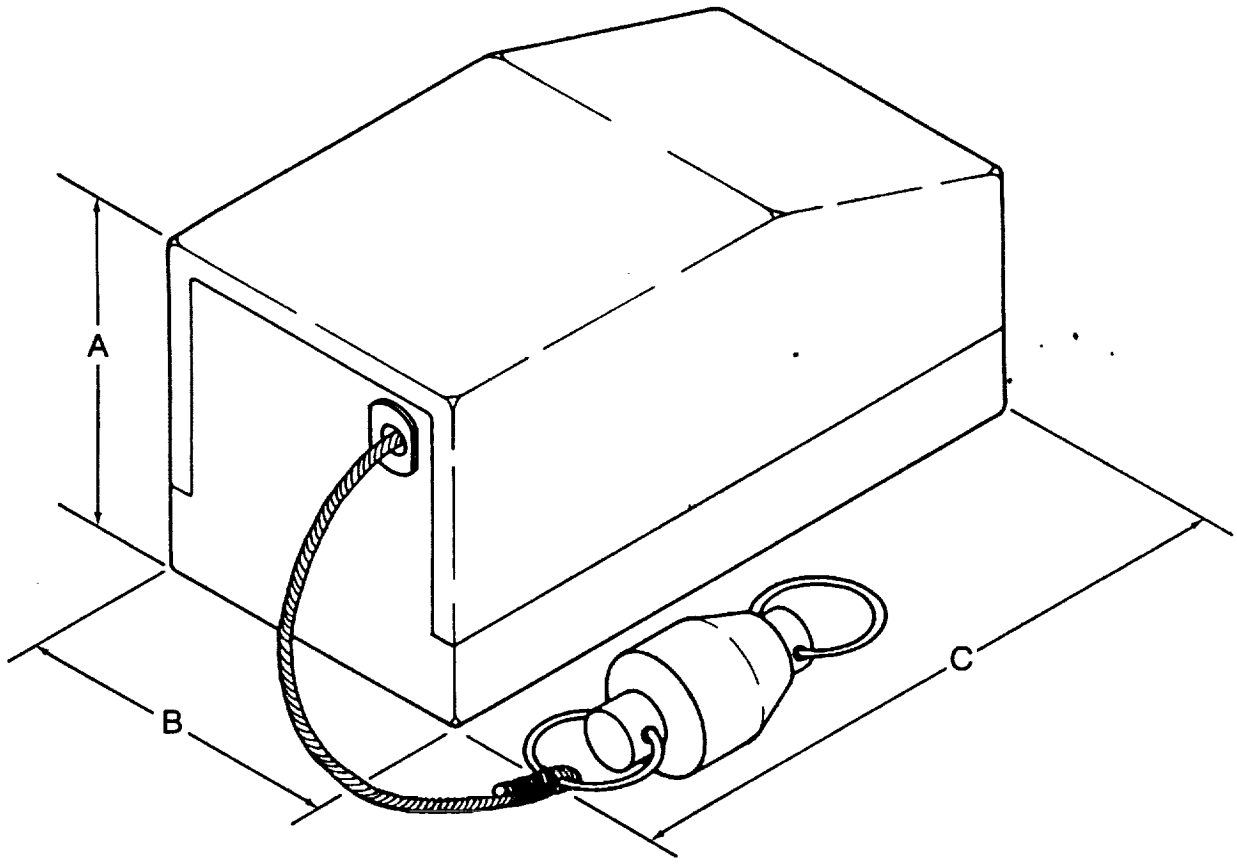
CONTACTS

Source: M. Withey, ILC Space Systems, (713)488-9080
Operational: R. C. Trevino, NASA/JSC/DF, (713)483-2597

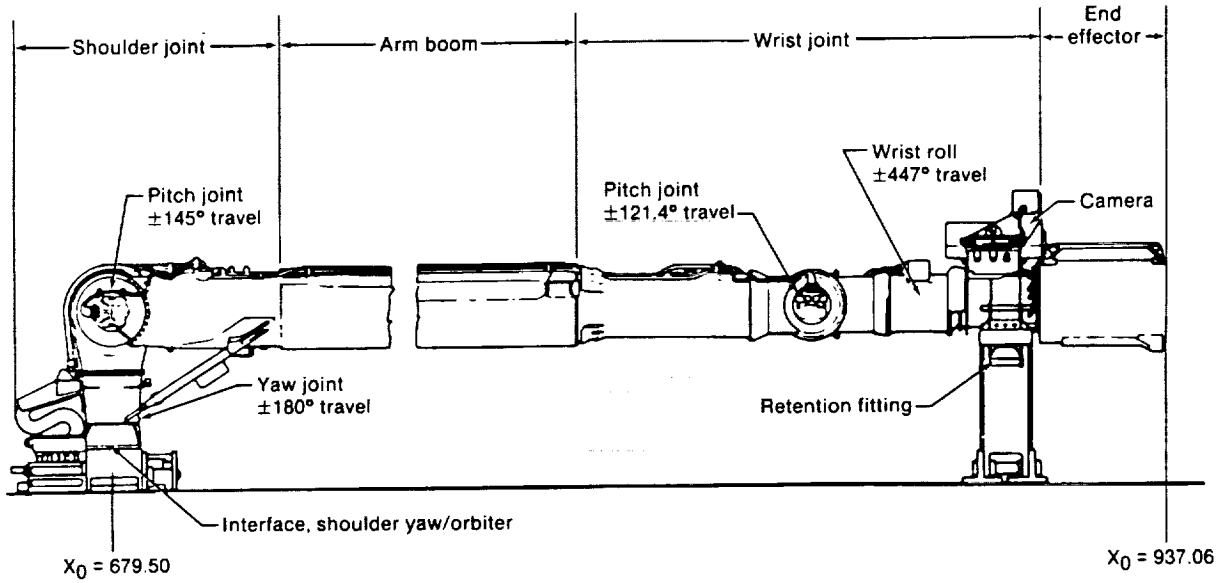
RETRACTABLE TETHER

Technical Information	
Part Number	10153-20004-01 Vespel case 10153-20004-02 aluminum case 10156-20027-02 aluminum case
Weight	0.14 lb
Material	Case-01 - aluminum allow Case-02 - Vespel Tether - 400 Denier Kevlar cord
Retracting Force	0.6 lb
Cord Breaking Strength	100 lb
Quantity Flown	Varies, used on tool caddies or tool boards
Stowage	Assembly dependent

Dimensional Data	
A	0.79 in.
B	1.24 in.
C	2.31 in.



RMS - Based Handling and Positioning Aid



OVERVIEW

The RMS-Based Handling and Positioning Aid (RMS/HPA) is a mechanical arm which provides a wide range of adjusable work stations both inboard and outboard of the Orbiter Cargo Bay. It is derived from Remote Manipulator System (RMS) technology.

OPERATIONAL COMMENTS AND INTERFACE PROVISIONS

The RMS/HPA is a mechanical arm attached to the Orbiter starboard longeron which will support, maneuver, and position payloads to permit inspection, servicing, construction, and repair. The design is modular and may be developed with up to six degrees of freedom; the four-joint version is shown above. It will be fitted with the RMS Standard End Effector or Special Purpose End Effector as a payload interface.

The shoulder yaw and shoulder pitch joints will be connected to the wrist pitch joint by a carbon composite boom. The RMS/HPA will be approximately 22 ft long to maintain the existing Manipulator Positioning Mechanism (MPM)/Manipulator Retention Latch (MRL) support equivalent to the Remote Manipulator System.

The RMS/HPA will be mounted on the starboard side of the Orbiter in the position designated for the starboard side RMS. It will be maneuvered on a joint-by-joint basis with brakes applied when a joint is not commanded to move. The single-joint, direct-drive, and back-up modes will be controlled from the RMS display and control panel.

STATUS

The RMS/HPA is a concept that was developed through critical design review. The system utilizes existing flight qualified hardware.

RMS - BASED HANDLING AND POSITIONING AID

CONTACTS

Source: Spar Aerospace Limited, Remote Manipulator Systems Division,
1700 Ormont Drive, Weston, Ontario, Canada M/L 2W7

Operational: B. Fuller, Spar, (416)745-9680 Telex: 065-27360
J. Lindemenn, MP, (713)483-5202.

REFERENCES

HPA Requirements Definition Document. SPAR, HPA-SG701.
HPA Contract End Item Specification. SPAR, HPA-SG739.

Robocon

OVERVIEW

This series of subminiature connectors has been designed for robotic/ manipulator, hand, EVA glove, and blind-mate modes of operation for serviceable spacecraft, payloads, and instrumentation applications.

OPERATIONAL COMMENTS AND INTERFACE PROVISIONS

The connector incorporates the scoop-proof, EMI, backshell, and other features of the MMS S-700-42 blind-mate connector technology and includes the use of long-lasting, low-insertion/low-withdrawal force, low-resistance contacts. For the manipulator, hand, and EVA glove modes, the connectors are equipped with an automatic latching mechanism which retains the mated connector until the release mechanism is pressed permitting easy release of the mated pairs. For blind-mate applications, one of the connectors halves is firmly mounted with the opposite half float mounted to provide a plus or minus ten degree and plus or minus 0.12 inch translational error without bending contacts. There are plans for 30, 60, & 90 contact versions as well as provision for coaxial, twinaxial, triaxial, and optical couplers. Models have been made of a larger version for space station power distribution use employing a flat ribbon form of interconnection.

STATUS

Concept models of the subminiature and power type of Robocons have been designed and produced by the contractor and given preliminary tests.

CONTACTS

Source: NASA/GSFC SSP/CODE 408.0
Operational: R. E. Davis (301)286-2260 or
D. R. Manges (301)286-2431

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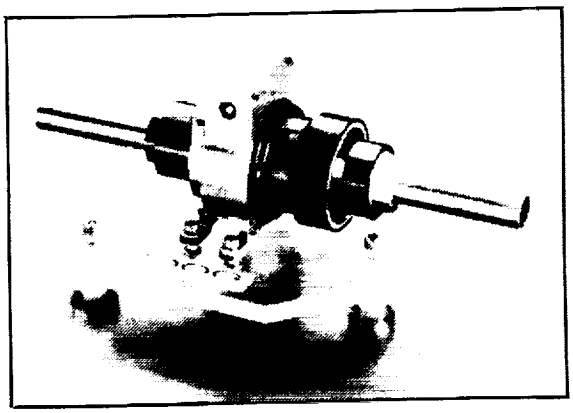
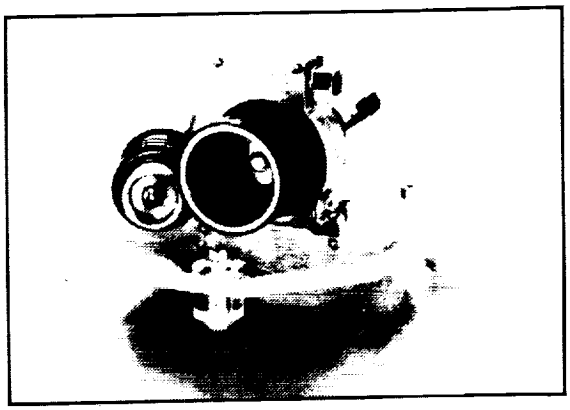
Rotary Shut-Off Fluid Connector





OVERVIEW

The MOOG Rotary Shut-Off (RSO) design provides a fluid coupling that has minimal pressure loss across the unit and minimal leakage during connection/disconnection operations.

OPERATIONAL COMMENTS AND INTERFACE PROVISIONS

Some of the features of the MOOG RSO Fluid Connector are as follows:

- Zero leakage during connection/disconnection if the purge option is utilized.
- Disconnect valving elements automatically open or close during act of connection or disconnection.
- Triple redundant o-rings seal the unit against external leakage when connected.
- Valving element seals can be checked for leakage (verified) before the unit is disconnected.
- Unobstructed flow path has a minimal pressure drop.
- Actuation can be accomplished by a suited astronaut with standard tools, by a remote manipulator arm or remotely via an optional motor.
- Once fully engaged, the disconnect forms a rigid structural as well as hydraulic connection.

STATUS

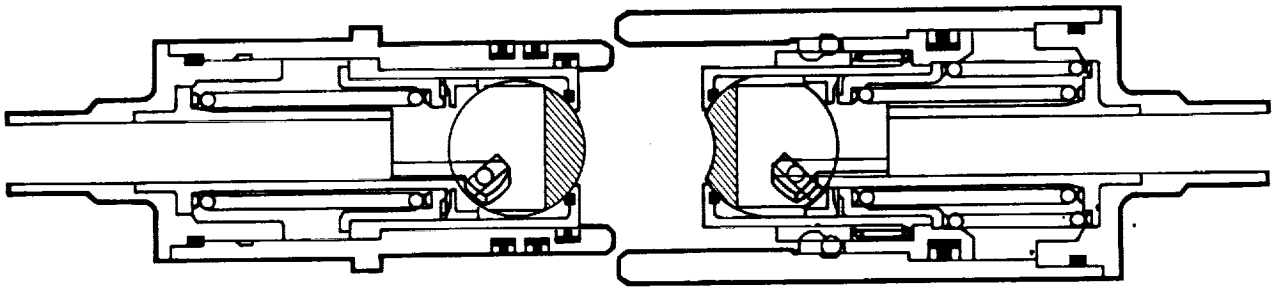
The RSO Coupler is being manufactured and tested.

CONTACTS

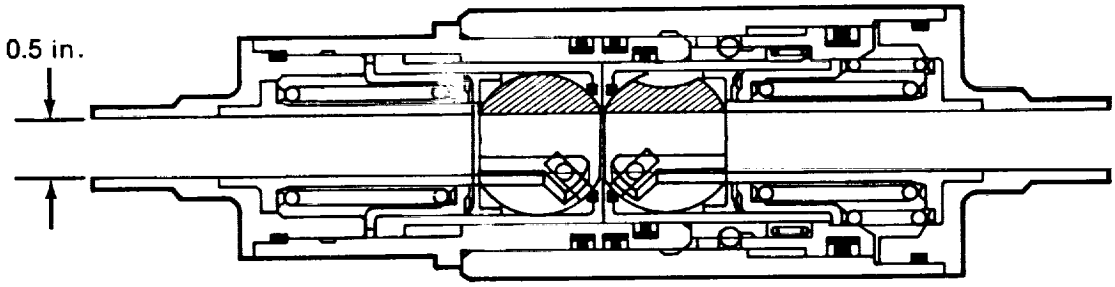
Source: MOOG Space Products Division
East Aurora, NY 14052
Operational: Joseph M. Cardin, MOOG, (716)667-4417

ROTARY SHUT-OFF FLUID CONNECTOR

Specifications	
Less than 50 in. lb. force required to engage/disengage under full system pressure of 620 psi	
External Leakage	1.0×10^{-8} SCCS GHe at 620 psi
Spillage	0.07 cm^3
Pressure Drop	0.75 psid at 5.0 gpm H_2O
Cycle Life	1000 connect/disconnect
Engagement Torque	40 in. lbf.
Capture Force	20 lbf.
Stroke	1.8 in. including capture mechanism
Weight	1000 grams
Material	Aluminum



Disengage Configuration



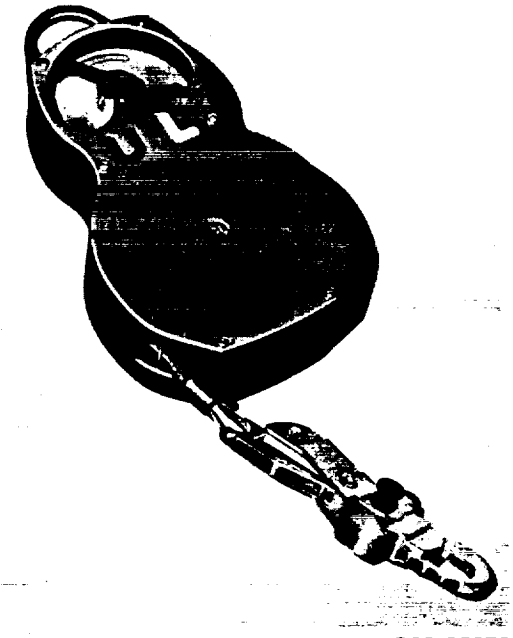
Engage Configuration

Safety Tether, 35-Foot

OVERVIEW

The 35-foot safety tether connects the crewmember to a slide wire along the cargo bay sill longeron during EVA. The tether consists of a reel case with an integral D-ring, a take-up reel, a 35-foot cable, and a locking hook. A selector on the reel case can be set to lock the take-up reel or to unlock it to allow the tether to reel out and retract.

The locking hook on the tether incorporates a lock-lock feature to prevent accidental opening.



S82-35970

OPERATIONAL COMMENTS AND INTERFACE PROVISIONS

For launch and entry, the port and starboard safety tethers are stowed in a cloth-covered stowage container which is secured to the bulkhead above the airlock in the cargo bay. While still in the airlock, after opening the airlock hatch, a crewmember attaches a waist tether to the D-ring of the safety tether. (The other end of the waist tether is hooked to a ring on the EMU waist bearing.)

A series of straps, clips, and a small capstan secures the 35-foot tether between the slide wire and airlock during launch and entry. The tether is secured near handrails to allow the crewmember to unstow it while moving to the work area and to restow it while returning to the airlock after finishing the EV task.

STATUS

Flight qualified. Flown on all STS flights.

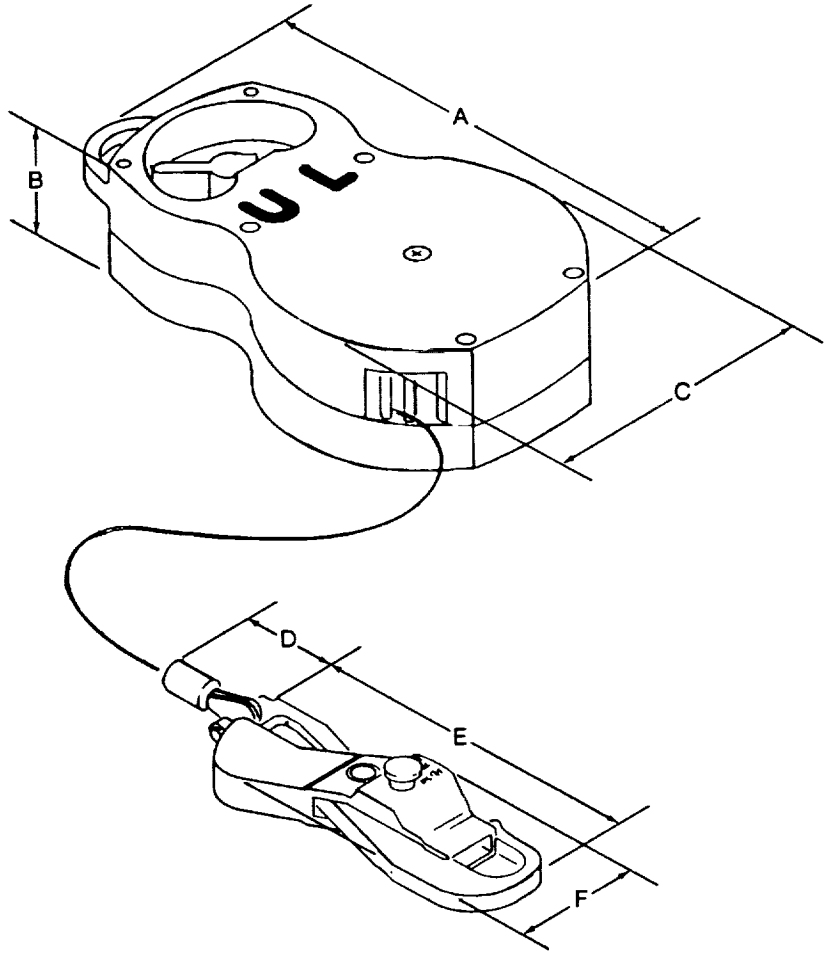
CONTACTS

Source: M. Withey, ILC Space Systems, (713)488-9080
Operational: R. C. Trevino, NASA/JSC/DF, (713)483-2597

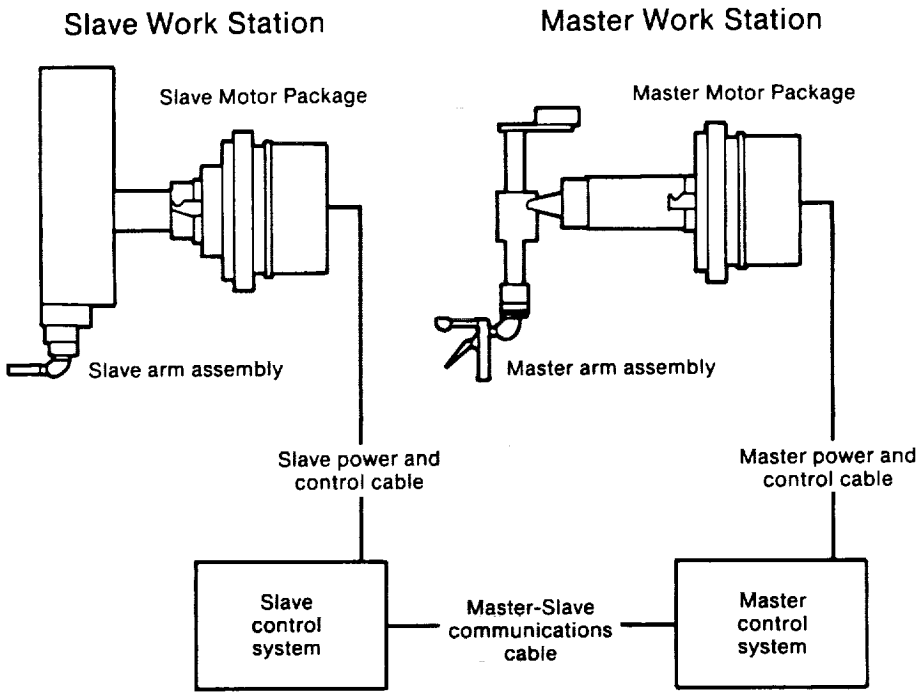
SAFETY TETHER, 35-FOOT

Technical Information	
Part Number	10153-20004-01 Vespel case 10153-20004-02 aluminum case 10156-20027-02 aluminum case
Weight	0.14 lb
Material	Housing - aluminum, stainless steel Tether - stainless steel cord, 3/32-in. dia.
Load Limit	Cable - 920 lb
Retracting Force	1.5 lb
Takeup Force	0.5 lb
Quantity Flown	Two
Stowage	Payload bay X_o - 576 bulkhead

Dimensional Data	
A	8.360 in.
B	2.086 in.
C	4.490 in.
D	1.5 in.
E	5 in.
F	1.75 in.



SAMSIN Master-Slave Servo Manipulator



OVERVIEW

SAMSIN (Servo-Actuated Manipulator System With Intelligence Networks) is a bilateral force reflecting master-slave servo manipulator. SAMSIN is a general purpose electrical-mechanical device. (SAMSIN is a registered trade mark.)

OPERATIONAL COMMENTS AND INTERFACE PROVISIONS

SAMSIN is used to extend the hand and arm manipulative capacity into a "remote hostile" environment. A master-slave manipulator is an extension of the human hand. The remote hand may be used as a tool, but can be used more effectively as the hand that holds and guides a tool. SAMSIN has seven degrees-of-freedom and is bilateral and force reflecting in all degrees-of-freedom.

STATUS

SAMSIN units are available on a production basis for use as engineering development test beds, for use in irradiation testing facility operations and are being specified by contractors for the DOE fuel rod consolidation program. On going development including/B demonstrations.

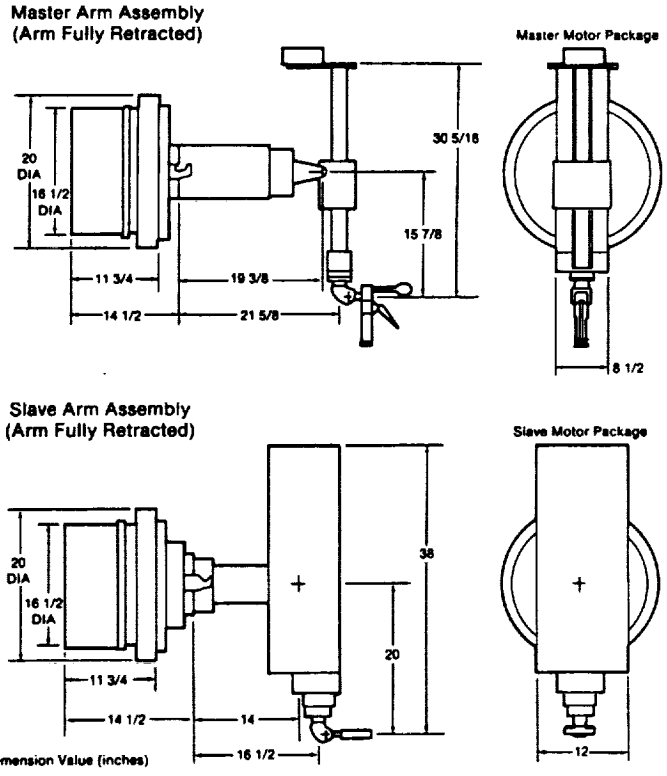
CONTACTS

Source: Central Research Laboratories, P. O. Box 75, Redwing, MN 55066
Operational: R. Adams, CRL, (612)388-3565

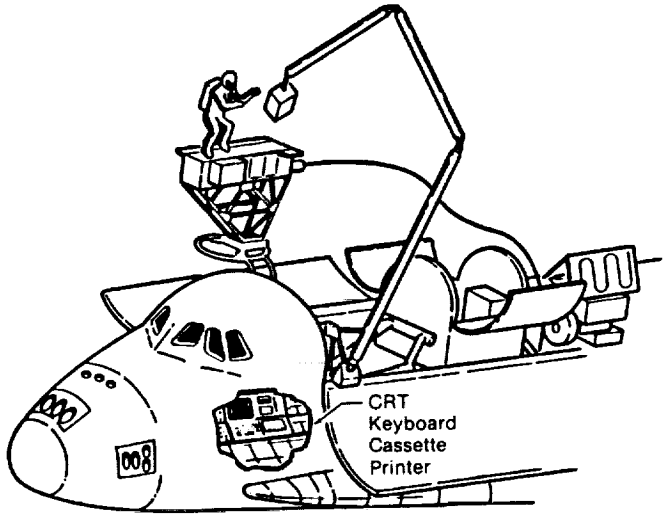
SAMSIN MASTER-SLAVE SERVO MANIPULATOR

Technical Information		
Weight	Master arm assembly Master motor package Slave arm assembly Slave Motor Package *includes counterbalance weights	65 lbs.* 170 lbs. 90 lbs.* 180 lbs.
Power Req	Master arm system Slave arm system	1000 watts 1000 watts
Temperature	0° to 55° C	
Remote Handling Capacity	15, 20, or 50 lbs.	
Master Force Reflection Capacity	15 lbs.	
No-Load Slewing Rate	40 in/sec.	

	Interface Details
Electronics	RS-232, Multibus I or II VME, or Q bus, or PC bus
Electrical	120 VAC, single phase or 240 VAC, three phase 60 Hz.
Tool	Remotely interchangeable tong jaws for alternate end effectors or tools
Slave Work Station Mounting Interfaces	Universal mounting plate attachment provided on motor pkg.



Satellite Checkout Equipment



OVERVIEW

The Satellite Checkout Equipment provides checkout/diagnostic capability for payloads prior to launch, on-orbit deployment or during maintenance/repair. Operates independent of orbiter systems except for power and uplink, if required.

OPERATIONAL COMMENTS AND INTERFACE PROVISIONS

Payload bay mounted main computer with orbiter cabin displays and controls utilizes standard interfaces with payload.

Utilizes orbiter data links to accommodate customer ground compiled test sequences to be executed on-orbit.

STATUS

Concept

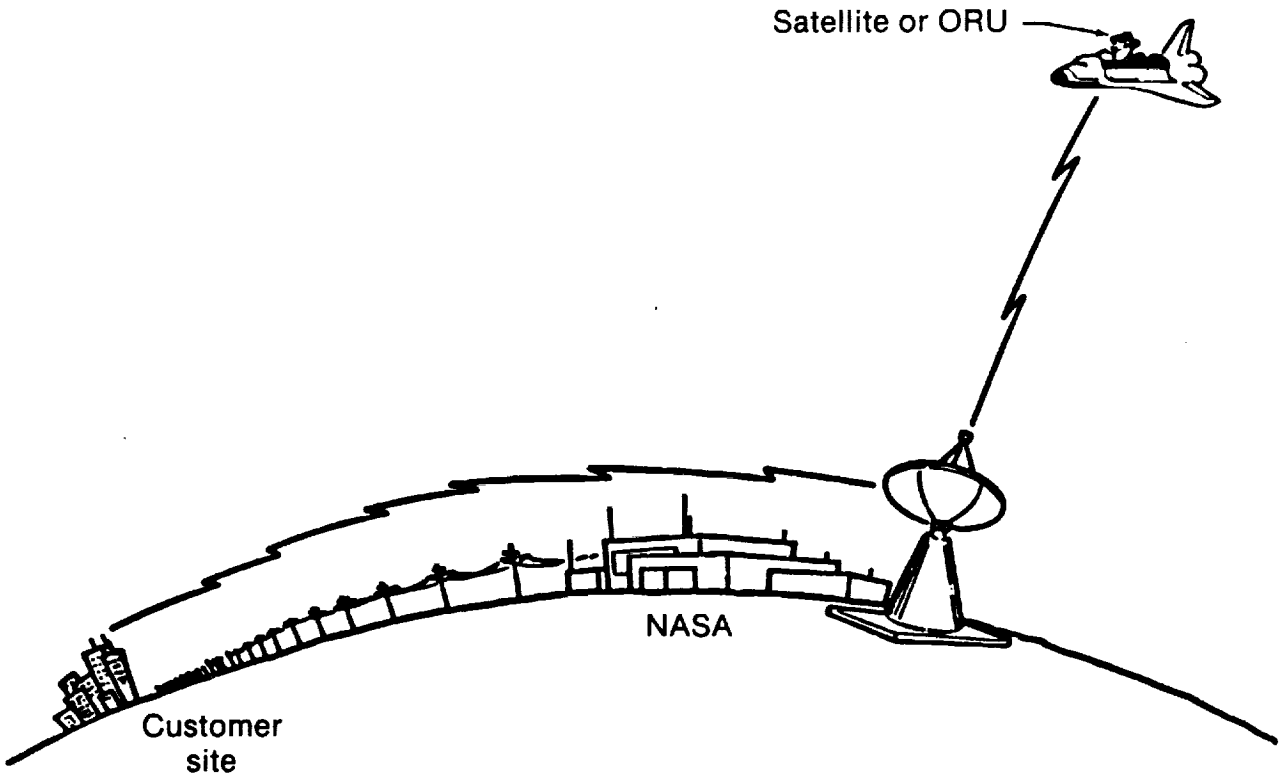
CONTACTS

Source: Rockwell International, 12214 Lakewood Blvd., Downey, CA 90241
Operational: C. W. Anderson, (213)922-5095
R. L. Gasteiger, (213)922-5339

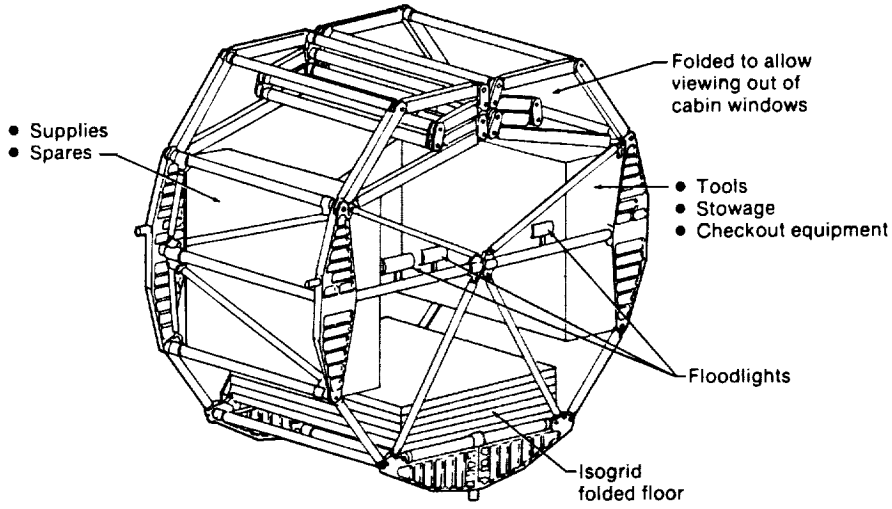
SATELLITE CHECKOUT EQUIPMENT

Technical Information	
Weight	TBD
Power Req	TBD
Temp Range	TBD
Cooling	TBD
Material	TBD
Status	Concept

Interface Details	
Electrical	TBD
Mechanical	TBD
Data Rate	TBD
Documentation	TBD



Satellite Workshop



OVERVIEW

The Satellite Workshop is an expandable structure, covered with environmental resistant fabric surface, provides an EVA enclosure with environmental protection for personnel and equipment located outside the orbiter cargo bay during satellite servicing.

OPERATIONAL COMMENTS AND INTERFACE PROVISIONS

Stowed configuration utilizes about 8 ft of cargo bay length and expands to approximately 26 ft x 26 ft x 26 ft on orbit. Structure contains work area with constant lighting, storage for tools/equipment and payload attachment facilities.

EVA crew thermal/micrometeoroid garment (space suit) requirements can be reduced thus providing crewman increased flexibility/mobility.

STATUS

Concept

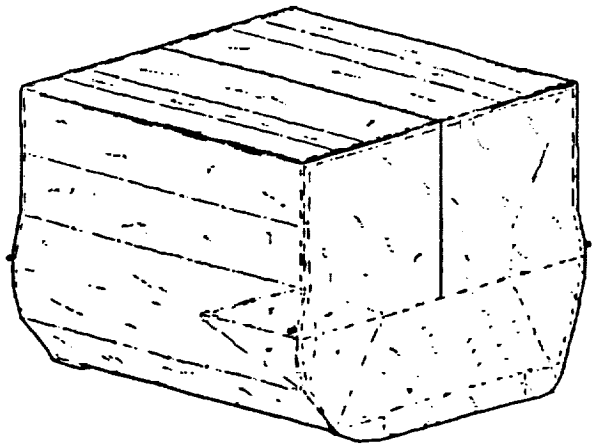
CONTACTS

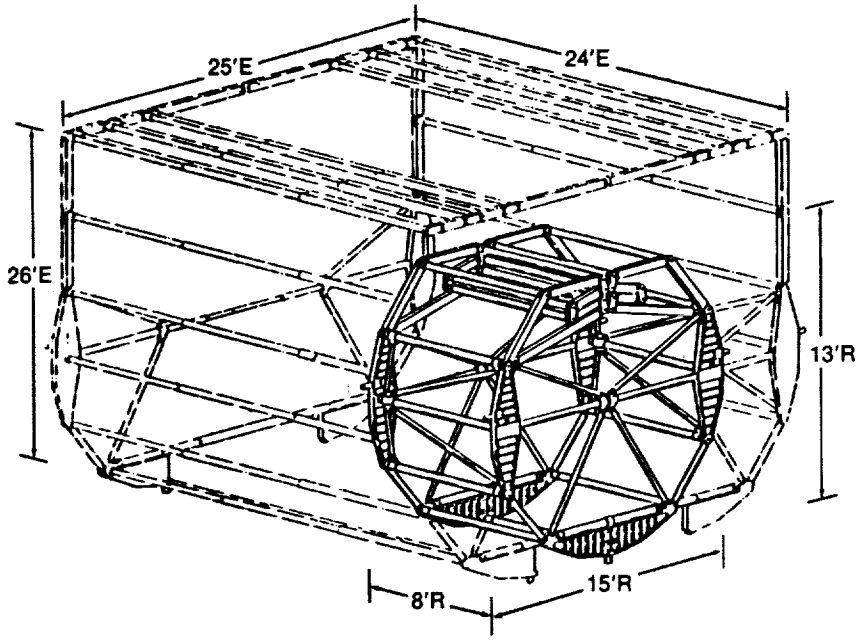
Source: Rockwell International, 12214 Lakewood Blvd., Downey, CA 90241
Operational: C. W. Anderson, (213)922-5095
R. L. Gasteiger, (213)922-5339

SATELLITE WORKSHOP

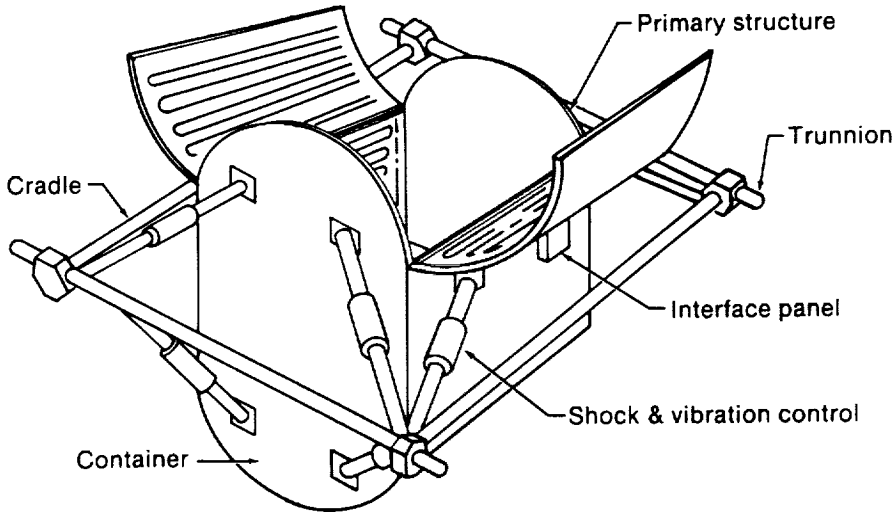
Technical Information	
Weight	TBD
Power Req	TBD
Temp Range	TBD
Cooling	TBD
Material	Aluminum/Fabric
Status	Concept

Interface Details	
Electrical	TBD
Mechanical	TBD
Data Rate	N/A
Documentation	TBD





Softride Container



OVERVIEW

The Softride Container mounted in the Orbiter cargo bay provides capability to carry sensitive payloads (un-ruggedized) into orbit by isolating shock and vibration levels to 1G.

OPERATIONAL COMMENTS AND INTERFACE PROVISIONS

Container utilizes an interface panel which provides electrical/fluid connections to payload. Container may be environmentally controlled thus providing capability to install payload at the "factory" and monitor/control payload until it reaches orbit without the need to open container.

STATUS

Concept

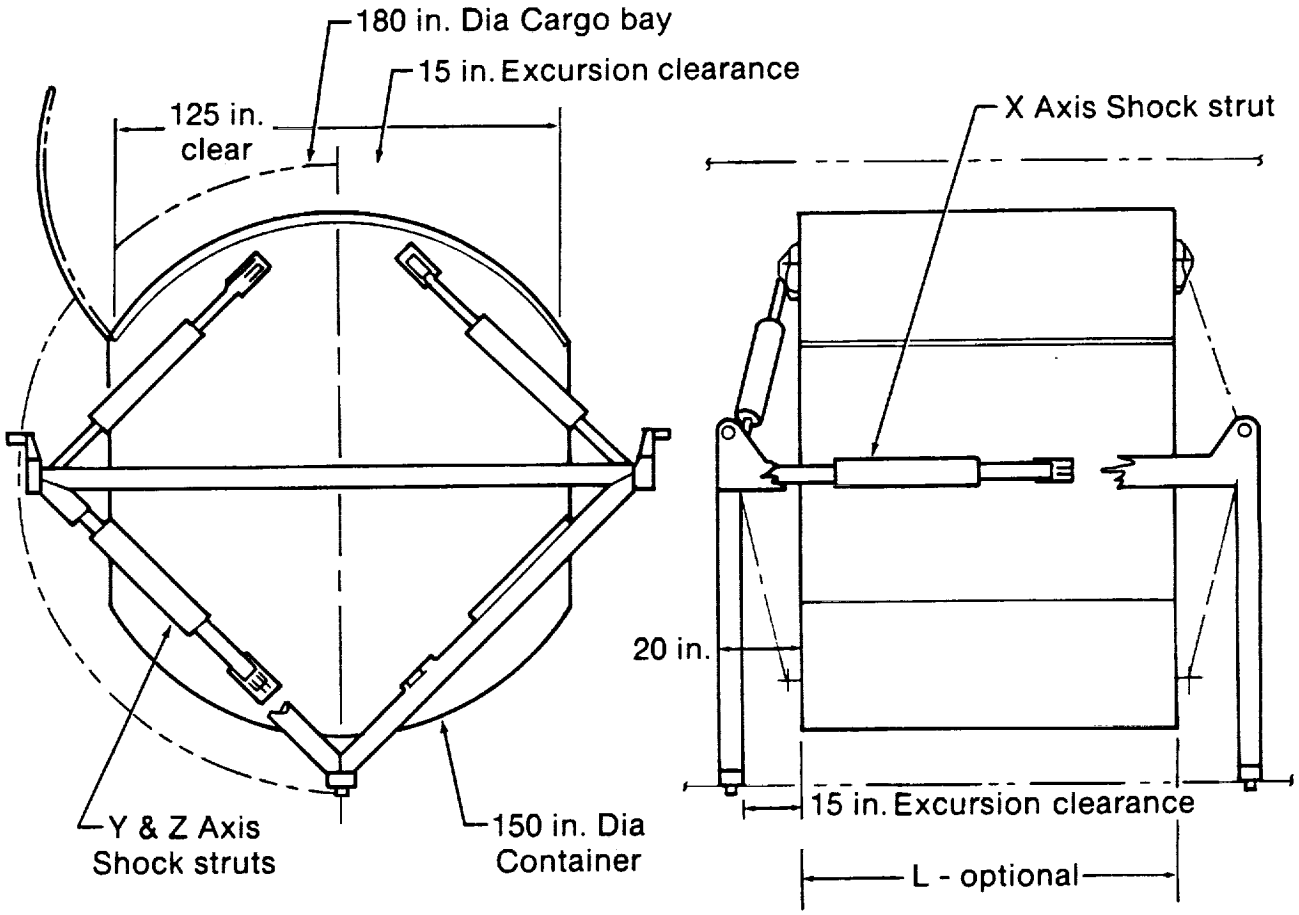
CONTACTS

Source: Rockwell International, 12214 Lakewood Blvd., Downey, CA 90241
Operational: C. W. Anderson, (213)922-5095
R. L. Gasteiger, (213)922-5339

SOFTRIDER CONTAINER

Technical Information	
Weight	TBD
Power Req	TBD
Temp Range	TBD
Cooling	TBD
Material	Aluminum
Status	Concept

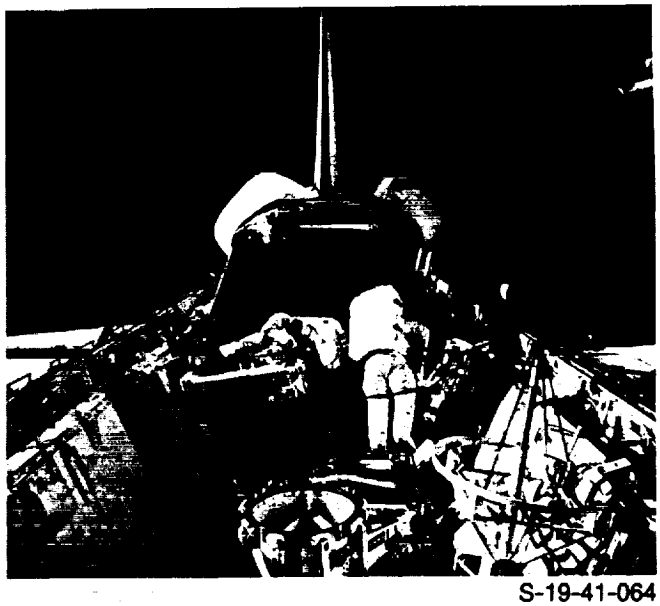
Interface Details	
Electrical	TBD
Mechanical	TBD
Data Rate	N/A
Documentation	TBD



Spacelab Pallet

OVERVIEW

The Orbital Flight Test (OFT) Pallet, called the Spacelab Pallet, is a specialized payload-carrying platform which provides mechanical, electrical, thermal, and control support to the attached payload.



S-19-41-064

OPERATIONAL COMMENTS AND INTERFACE PROVISIONS

The OFT Pallet is U-shaped and provides hard points for mounting heavy experiments and a large panel surface area to accommodate lighter payload elements. The carrier system contains a power distribution unit, a flex multiplexer/demultiplexer, a timing buffer system, a coolant pump, cold plates, necessary system plumbing and cabling, and a software interface to the Orbiter general purpose computer. Pallet segments are 3 meters in length and 4 meters in width, and they may be flown separately or in combination. Pallet configurations may consist of one to five pallet segments, and as many as three interconnected pallets can be supported by one set of Orbiter attachment settings. Pallets are controlled from the Orbiter Aft Flight Deck.

STATUS

Flight Qualified.

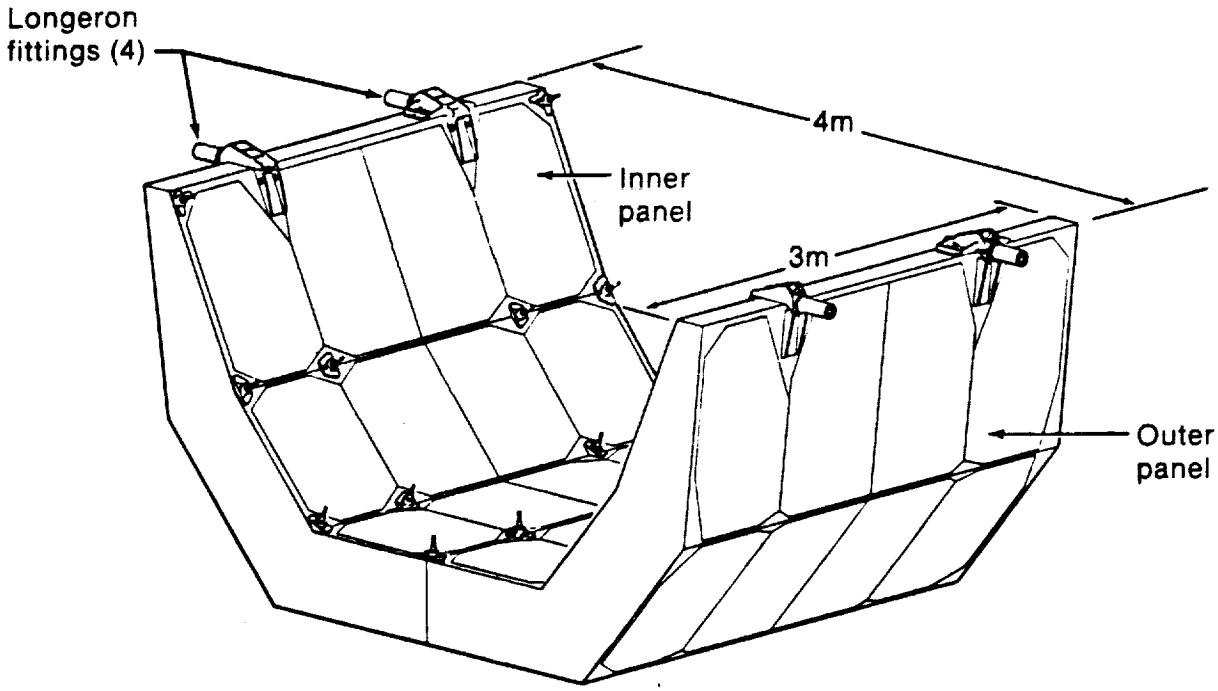
CONTACTS

Source: Marshall Space Flight Center
Operational: W. Johnson, MSFC, (205)453-2121

REFERENCES:

OFT Pallet System Carrier, Payload Integration Plan, Rev. B, JSC-14017, July 1980.
Shuttle Orbiter/Oft Pallet, ICD A-14017.
Spacelab Payload Accommodation Handbook, Rev. 2, SLP/2104, July 1979.

SPACELAB PALLET

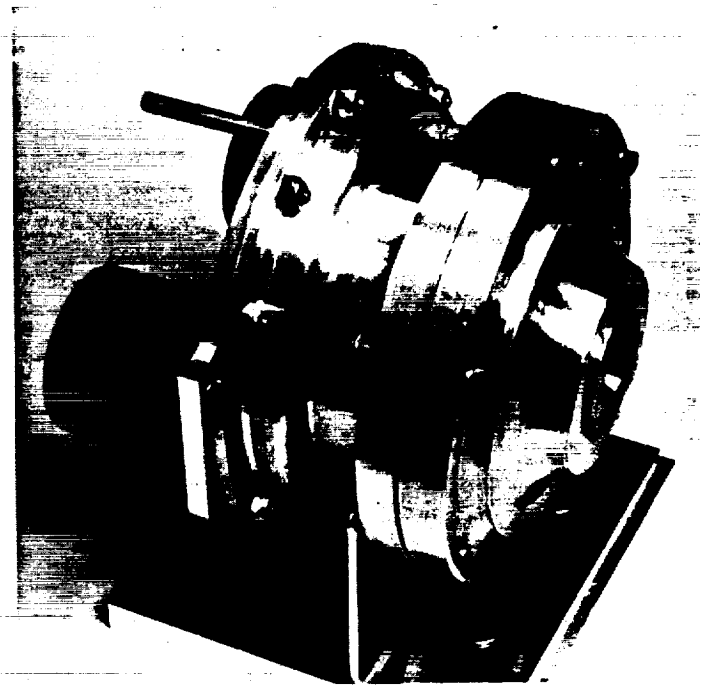


OFT Pallet Segment

Spin-Nut Hold Down Mechanism

OVERVIEW

The Spin-Nut Hold Down Mechanism, an electric motor-driven hold and release, self aligning mechanism was developed for in-orbit servicing and construction. The mechanism, designed for use on spacecraft or orbiting platforms, comprises a motor driven, free-floating, nut assembly that can be aligned with a threaded bolt protruding from the mating part. It is ideally suited for in-orbit repairs and replacements that require secure hold down of large equipment modules.



OPERATIONAL COMMENTS AND INTERFACE PROVISIONS

The Spin-Nut Hold Down Mechanism has design advantages including:

- Angular, axial and lateral self-alignment during mating operation.
- Completely remote operation to align, capture, hold and release a threaded protrusion on any space component.
- Appendage can be released remotely without loss of reattachment capability.
- Spar hold down equipment is available in various nut sizes and hold down torques, and can be supplied with either one of two drive motors that can be mounted to suit client configuration.
- The mechanism also features capture/release sensors and an anti-backdrive interlock.

STATUS

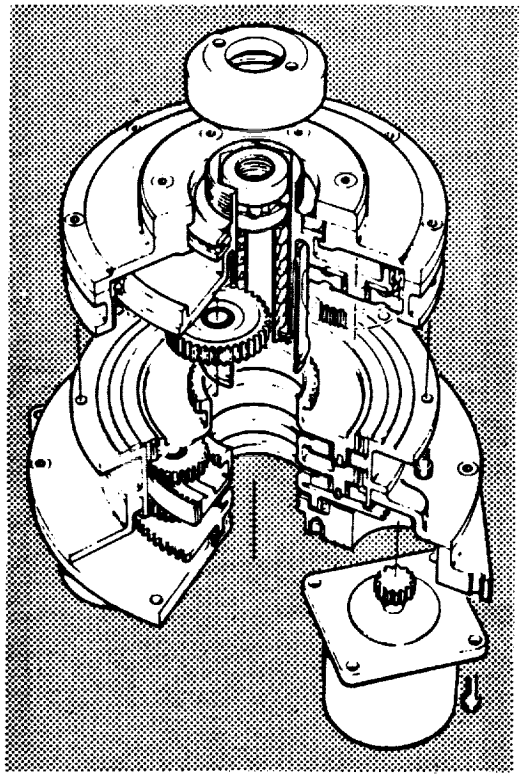
Engineering model undergoing performance testing. Under consideration for flight program.

CONTACTS

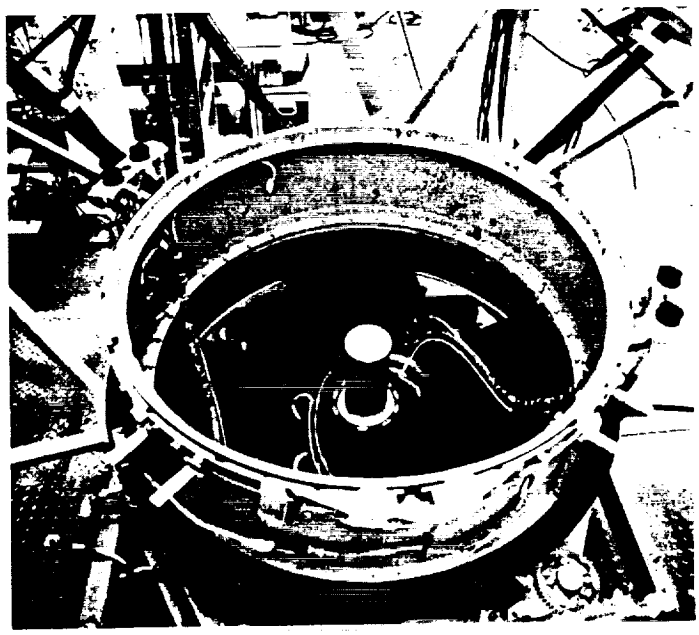
Source: Spar Aerospace Limited, 1700 Ormont Drive, Weston, Ontario, Canada M9L 2W7
Operational: B. Fuller, Spar/Business Development, (416)745-9680, Telex: 065-27360

SPIN-NUT HOLD DOWN MECHANISM

Technical Information					
Axial Draw Bar Rating	Mass (Less Motors)	Motor/Nut Ratio	Screw Size	Nut Torque	Radial Float
3000 lb	1.3 lb	90:1	.500 in	296 lb. in.	.025 in
6000 lb	1.5 lb	255:1	.500 in	600 lb. in.	.024 in
20000 lb	2.5 lb	1023:1	.750 in	2680 lb. in.	.036 in



Spin Table



S83-44606

OVERVIEW

The Spin Table provides the capability to "spin-up" a satellite prior to deployment from the Orbiter Cargo Bay.

OPERATIONAL COMMENTS AND INTERFACE PROVISIONS

The Spin Table is powered by redundant electric drive motors. Prior to deployment from the Orbiter, the satellite to be spun is held to the top of the Spin Table system by a clamp band. The clamp band is released by redundant bolt cutters, and separation springs on the Spin Table provide the initial separation impulse. In the event of an aborted mission after spin-up has been initiated, the drive motors will stop the rotation and the system will be returned to its original position.

STATUS

Flight qualified and has flown on several Shuttle missions.

CONTACTS

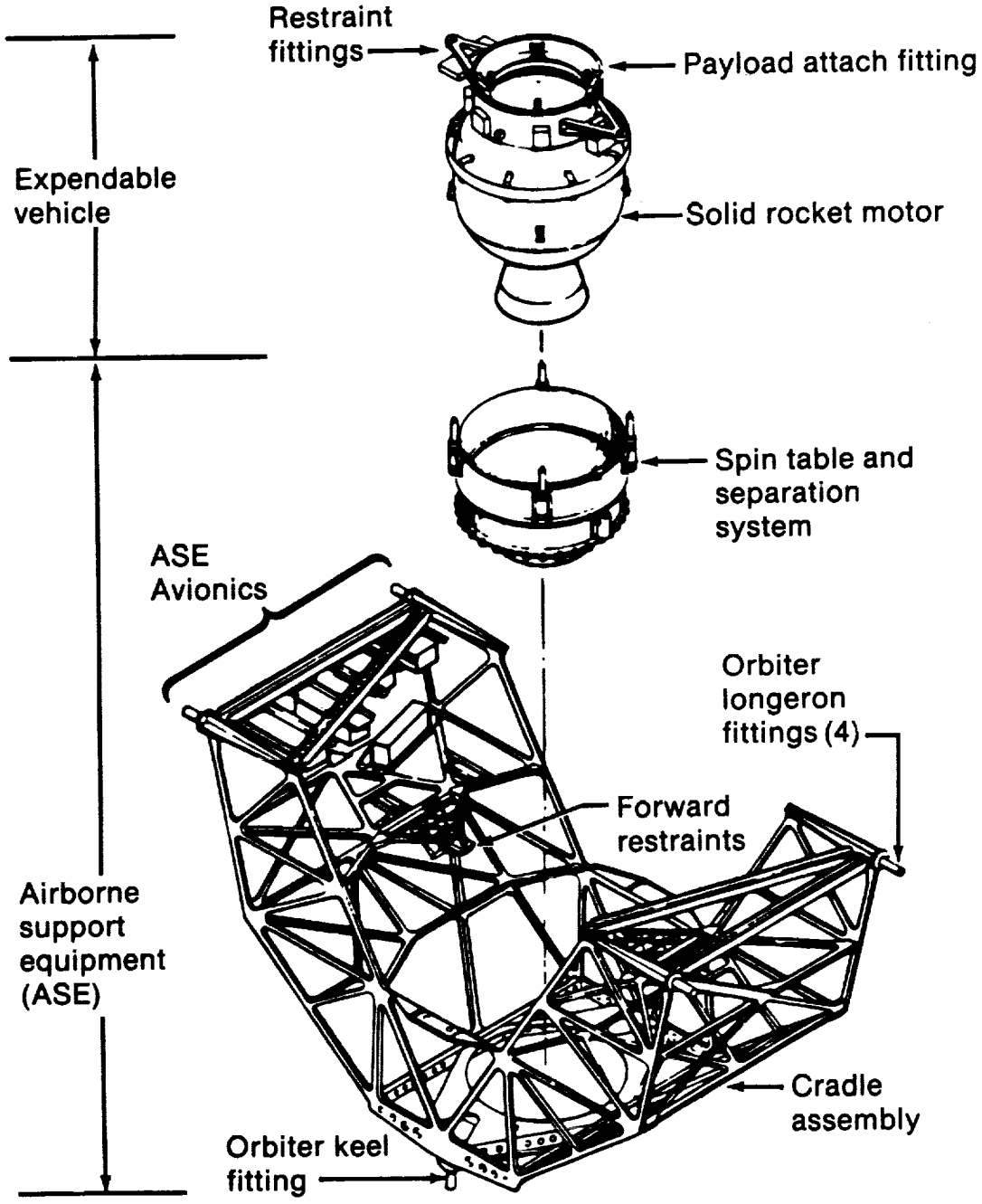
Source: McDonnell Douglas Corporation
Operational: George Wells, MDC, (713)483-5485

REFERENCES

PAM-D/PAM-D11 User Requirements Document. McDonnell Douglas, MDCG6626E.

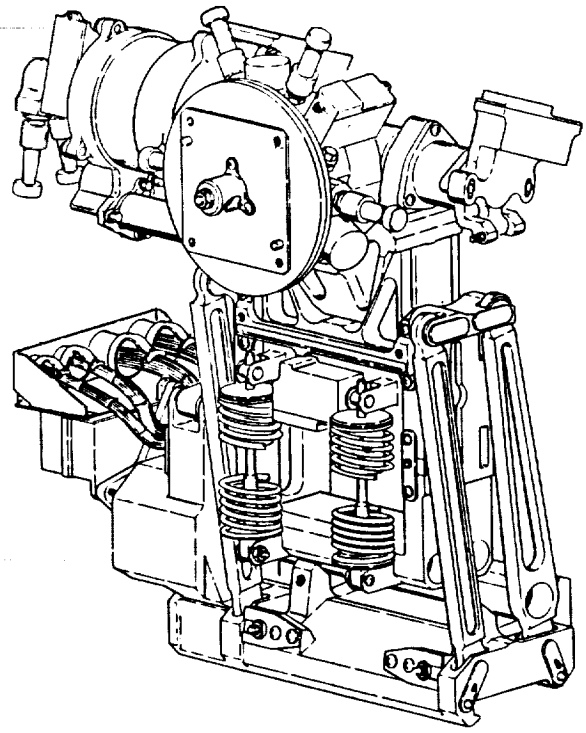
SPIN TABLE

Technical Information	
Initial Impulse Rate	2.5 ft/sec (minimum)
Nominal Rotation Velocity	50 rpm
Time to Nominal Rotation Velocity	80 to 80 sec



Stabilized Payload Deployment System

OVERVIEW



The Stabilized Payload Deployment System (SPDS) is a dual redundant motorized system designed to deploy RMS type payloads up to 50,000 pounds that are typically secured in the bay with "Port" side and starboard Payload Retention Latch Assemblies (PRLA's) and Active Keel Assemblies (AKA's). SPDS has been designed to operate from either port or starboard side of the payload bay. SPDS consists of a primary and a secondary pedestal attached to the Orbiter bridge fitting immediately behind each PRLA on the part side. Each pedestal consists of a payload interface plate, a rotary drive actuator, Z_O springs, a Y_O positioning mechanism, and a pyro disconnect assembly.

OPERATIONAL COMMENTS AND INTERFACE PROVISIONS

The payload interface plate attaches to both the separable portion of the disconnect assembly and the payload trunnion, providing the structural interface between SPDS and the payload. The SPDS is controlled and activated from the aft flight deck. There are no data or electrical connections between SPDS and the payload.

The deployment sequence is: open active keel assemblies (AKA's); open port PRLA's (Z_O springs extend 2 inches); drive Y_O positioning mechanism to outboard; open starboard PRLA's; and rotate payload 114° at 1/16 RPM.

Payload release is accomplished by firing 4 initiators attached to 3 pin pullers on each pedestal head assembly. Only one pin puller on each head is required to release the payload. Expulsion springs sized for specific payload mass and center of gravity are built into the pedestal heads. The springs provide a 1 inch per second expulsion rate.

STATUS

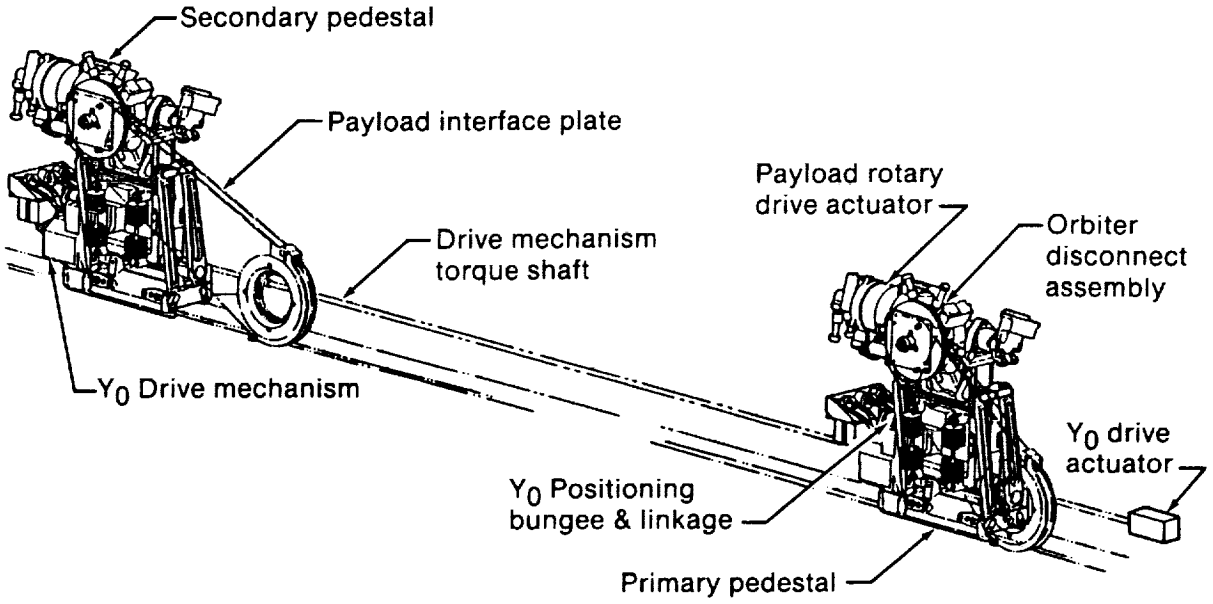
Flight hardware is scheduled to be available September, 1989.

CONTACTS

Source: Rockwell International
Operational: R. L. Farris, NASA/JSC/DF441, (713)483-0881

STABILIZED PAYLOAD DEPLOYMENT SYSTEM

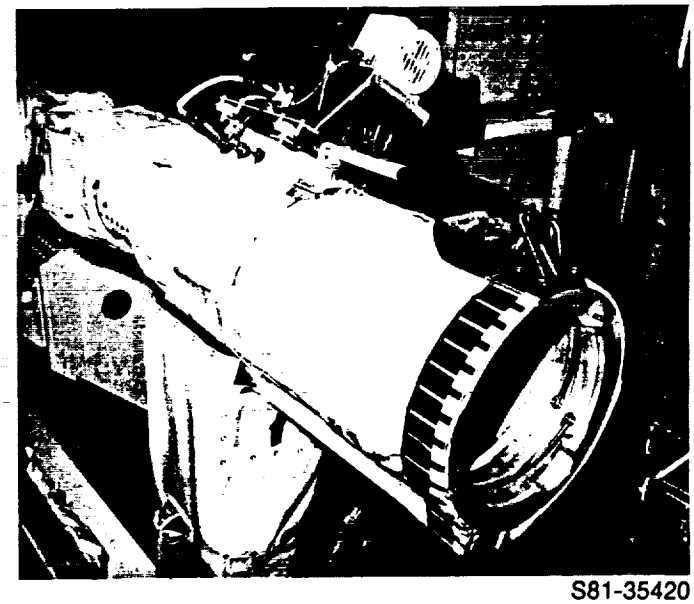
Technical Information	
Weight	Two pedestals, the Y_0 drive wiring and panel 180 lbs.



Standard End Effector

OVERVIEW

The Standard End Effector (SEE) is the terminal device on the Remote Manipulator System (RMS) arm, and its prime function is to capture, hold, and release payloads.



S81-35420

OPERATIONAL COMMENTS AND INTERFACE PROVISIONS

The SEE is a hollow, light-gauge aluminum cylinder which contains a remotely controlled motor drive assembly and three wire snares. The SEE drive system provides the abilities both to capture and release and to rigidize a payload. The capture/release function is achieved by rotating rings at the end of the unit which open or close the wire snares around the payload-mounted grapple fixture. The captured payload is rigidized when the same assembly is withdrawn into the end effector, pulling the payload into full contact with it. The SEE is controlled from the RMS control panel in the Aft Flight Deck of the Orbiter.

STATUS

The Standard End Effector is an integral part of the RMS.

CONTACTS

Source: SPAR, Canada
Operational: Ronald Zaguli, NASA/JSC/DF, (713)483-0887

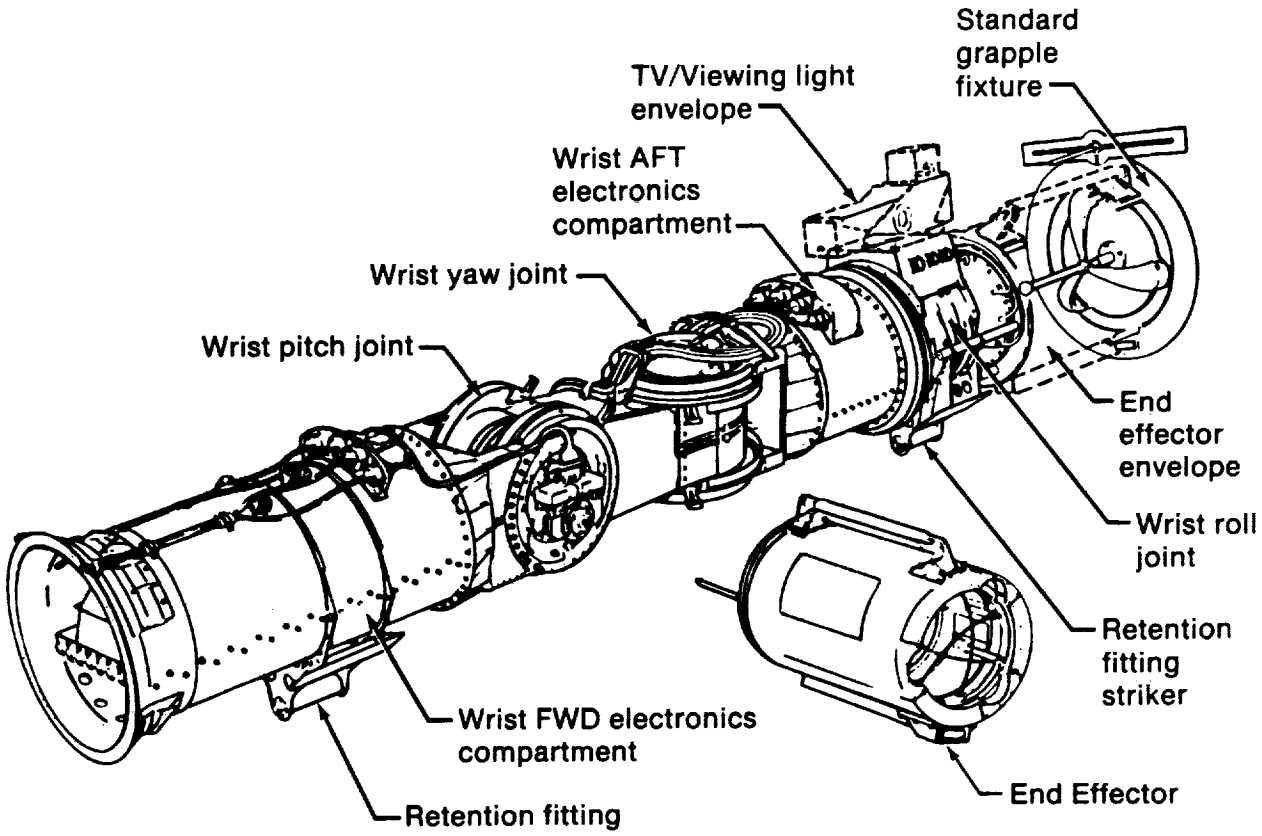
REFERENCES

Level II Program Definition and Requirements, Vol. 14, Space Shuttle System Payload Accommodations, Rev. G, Attachment 1. JSC-07700, ICD-2-19001, May 1983.

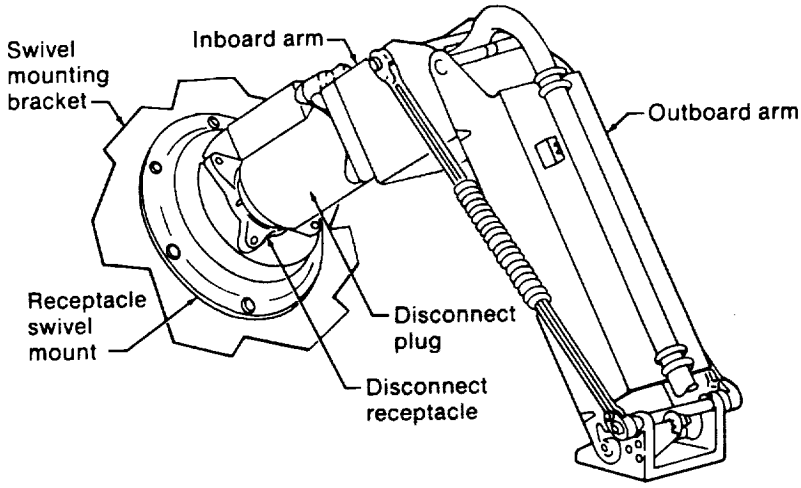
RMS Design Definition Report. SPAR-R.776, Issue E.

STANDARD END EFFECTOR

Specifications	
Length	21.5 in.
Diameter	13.6 in.
For other specifications, see RMS.	



Standard Umbilical Retraction-Retention System



OVERVIEW

The Standard Umbilical Retraction-Retention System (SURS) is designed to provide a separation system for the SPAS power and command-data electrical interfaces. Basic design was to provide separation capability only, however, remate may be accomplished by EVA.

OPERATIONAL COMMENTS AND INTERFACE PROVISIONS

Mounts on port or starboard bridge rail. After separation from the payload, the inboard arm retracts into the outboard arm, which is then stowed and does not penetrate the payload envelope.

Orbiter to payload relative motion is accommodated by a payload mounted monoball, the arm elbow joint, shoulder joint and rotating base.

Command/data disconnect - 128 pins (R.F., ML and HO)
Power disconnect - 18 pins (6 sets of 12 AWG)

STATUS

Successfully flown on a number of STS missions.
5 units fabricated - 2 command/data
2 power

CONTACTS

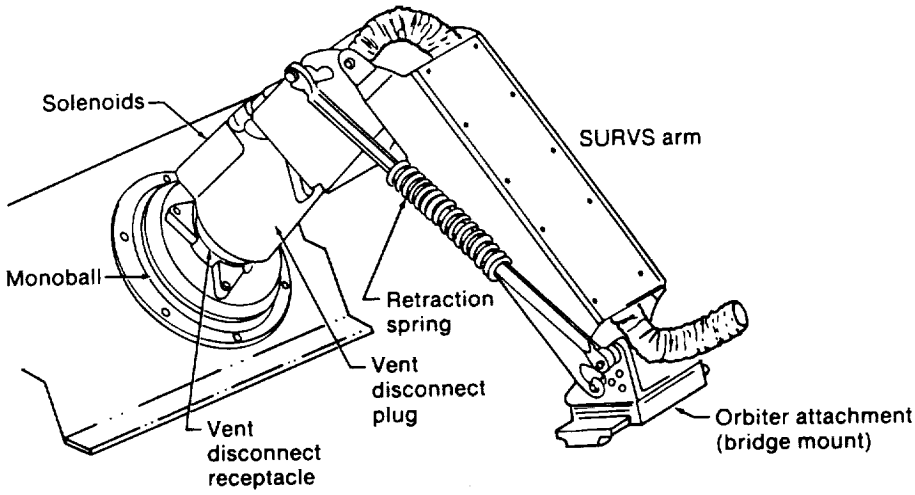
Source: Rockwell International, 12214 Lakewood Blvd., Downey, CA 90241
Operational: C. W. Anderson, (213)922-5095
R. L. Gasteiger, (213)922-5339

STANDARD UMBILICAL RETRACTION-RETENTION SYSTEM

Technical Information	
Weight	20 lbs.
Power Req.	N/A
Temp Range	75° F to + 200· F (-40° F to + 100° F prior to and during disconnect operations)
Cooling	N/A
Material	Aluminum
Status	Flight qualified

Interface Details	
Electrical	See ICD-A-14024 and ICD-2-19001
Mechanical	See ICD-A-14024 and ICD-2-19001
Data Rate	N/A
Documentation	Design Requirements Doc. STS81-0055

Standard Umbilical Retraction Vent System



OVERVIEW

The Standard Umbilical Retraction Vent System (SURVS) is an orbital vent disconnect system, based upon the SURS electrical disconnect system, with electrical plug and receptacle inserts and cabling replaced with vent inserts and plumbing.

Basic design provided for separation capability only, however, remate may be accomplished by EVA.

OPERATIONAL COMMENTS AND INTERFACE PROVISIONS

Mounts on port or starboard bridge rail. After separation from the payload, the inboard arm retracts into the outboard arm, which is then stowed and does not penetrate the payload envelope.

Orbiter to payload relative motion is accommodated by a payload mounted monoball, the arm elbow joint, shoulder joint and rotating base.

Utilizes a 3/4 in. vent disconnect with a vent insert seal capable of maintaining a leak rate less than 10^{-4} standard cubic centimeters per second at an operating pressure (vacuum) of 0.5 PSI.

STATUS

One unit fabricated for the COBE program.

CONTACTS

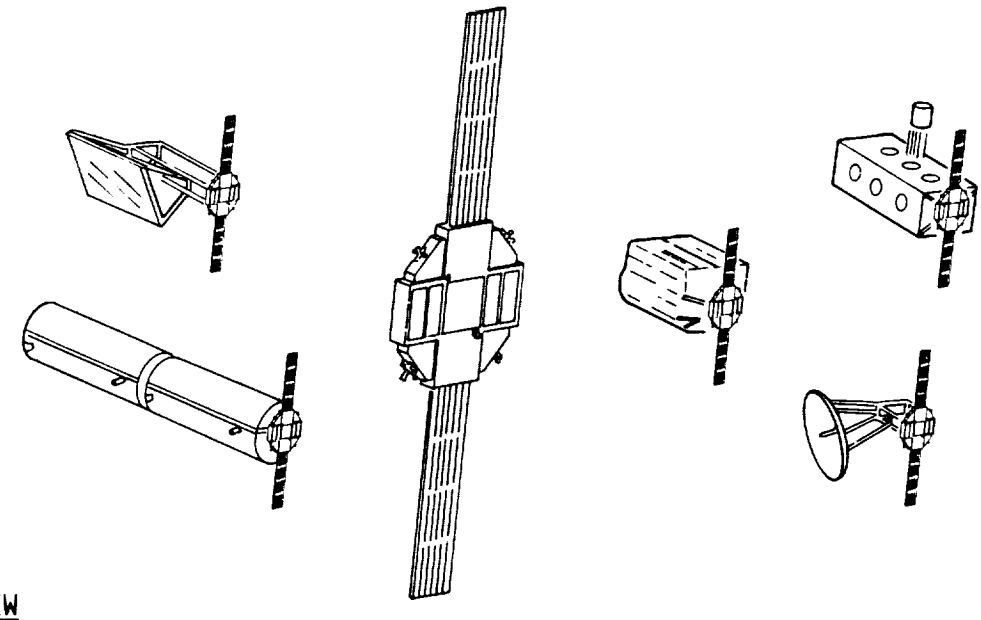
Source: Rockwell International, 12214 Lakewood Blvd., Downey, CA 90241
Operational: C. W. Anderson, (213)922-5095
R. L. Gasteiger, (213)922-5339

STANDARD UMBILICAL RETRACTION VENT SYSTEM

Technical Information	
Weight	17 pounds
Power Req	N/A
Temp Range	-70° F to +200° F (-40° F to +100° F prior to and during disconnect operations)
Cooling	16101-10061-01
Material	6.5 lbs.
Status	6.5 lbs.

Interface Details	
Electrical	28 V DC. external via power cord
Plug Part	# 860547765-8P (GFE)

Strap - On Attitude Control System



OVERVIEW

The Strap-On Attitude Control System (SACS) provides three-axis control and stabilization. Capable of being attached to payload by RMS or EVA, in low earth orbit, or by OMV, in high/low earth orbit.

OPERATIONAL COMMENTS AND INTERFACE PROVISIONS

"STRAP - ON" capability provides variety of applications:

- Stabilize disabled satellites until repaired
- Provides "Parking Capability" for payloads
- Hold any object as a target
- Holds payloads during assembly or subassembly build-up on-orbit

STATUS

Concept

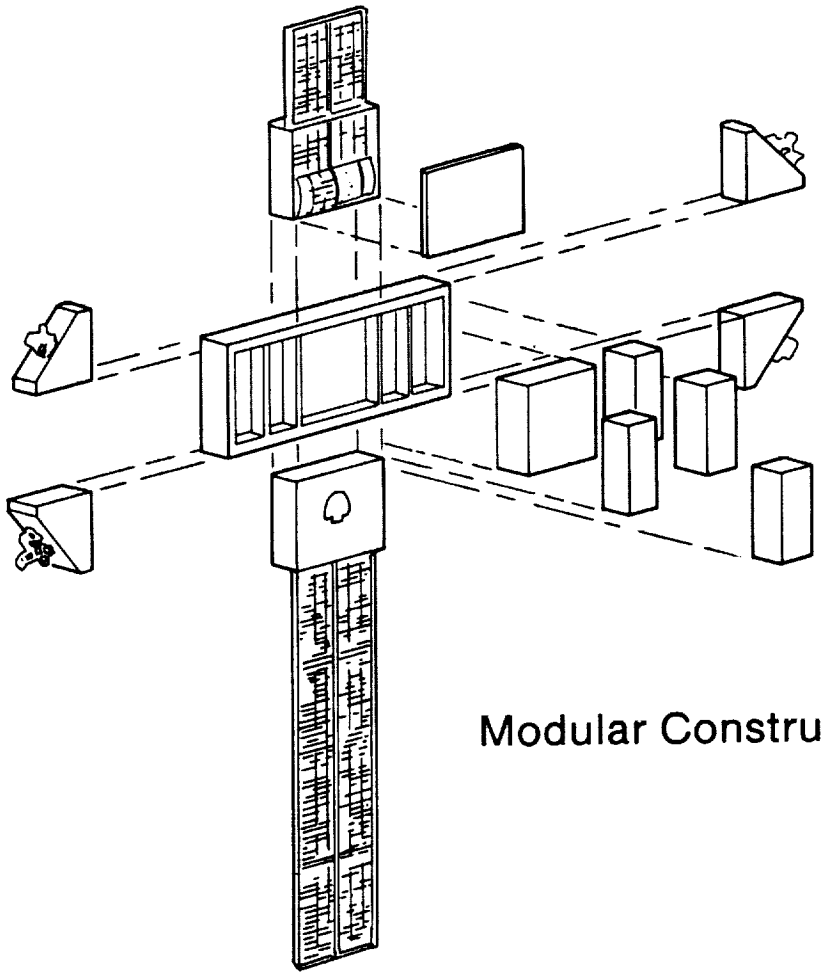
CONTACTS

Source: Rockwell International, 12214 Lakewood Blvd., Downey, CA 90241
Operational: C. W. Anderson, (213)922-5095
R. L. Gasteiger, (213)922-5339

STRAP-ON ATTITUDE CONTROL SYSTEM

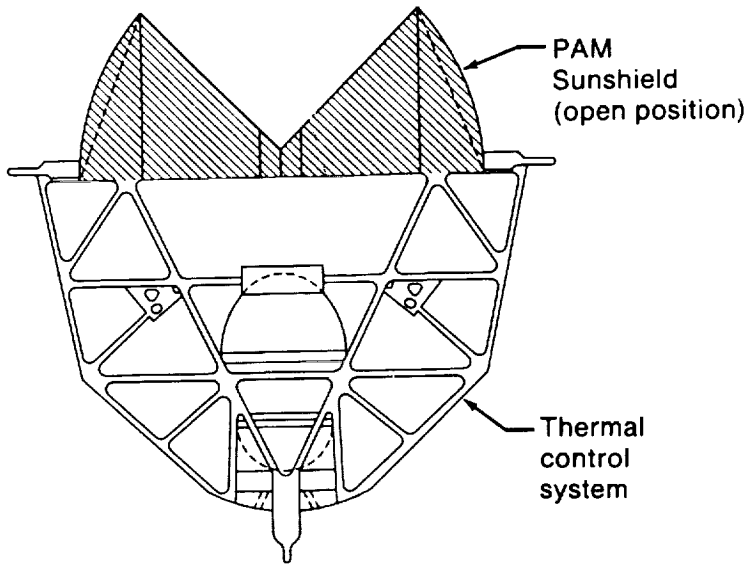
Technical Information	
Weight	<1200 lb
Power Req	TBD
Temp Range	TBD
Cooling	TBD
Material	TBD
Status	Concept

Interface Details	
Electrical	<1200 lb
Mechanical	Transported in Cargo Bay utilizing Trunnion/Keel fittings
Data Rate	N/A
Documentation	TBD



Modular Construction Concept

Sun Shield



OVERVIEW

The Sun Shield provides protection to sun-sensitive payloads.

OPERATIONAL COMMENTS AND INTERFACE PROVISIONS

The Sun Shield provides sun-impingement protection to a payload with the Cargo Bay doors open. The shield is retracted whenever the Cargo Bay doors are closed. As the Cargo Bay doors open, the shield closes automatically to envelop the payload as illustrated above.

As presently conceived, the large area surface of the Sun Shield is composed of thin-film insulation and can be modularly adaptable to accommodate payloads of varying lengths. The deploy-on-orbit approach minimizes the weight of the unit by eliminating the need for the shield to accommodate structural/vibration loadings during launch.

STATUS

Flight qualified. Flown on specific STS flights.

CONTACTS

Source: MDAC, Huntington Beach, CA
Operational: Wayne Wedlake, NASA/JSC/DF42, (713)483-2568

REFERENCES

Shuttle Orbiter PAM-D Class Cargo Element Interfaces. ICD-A-14005.

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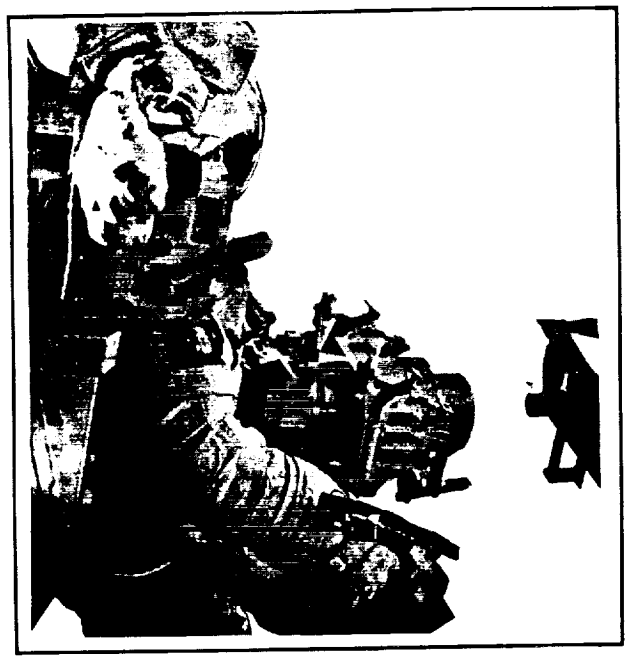
Trunnion Pin Attachment Device



S84-27030

OVERVIEW

The Trunnion Pin Attachment Device (TPAD), mounted on the Manned Maneuvering Unit (MMU), is used to capture and stabilize a multimission modular spacecraft (MMS)-type satellite. It can also be used to attach a grapple fixture to a satellite for connection to the Remote Manipulator System (RMS).

OPERATIONAL COMMENTS AND INTERFACE PROVISIONS

The TPAD consists of three parts: the control assembly, the primary assembly, and the secondary assembly. All are attached to the MMU by two brackets held by pip pins. The control assembly provides jaw action and locking control and allows the primary assembly to be detached from the control assembly. The primary assembly attaches the crewmember and MMU to the TPAD satellite for stabilization. A secondary TPAD assembly may be rotated up to take the place of the primary TPAD assembly in case of a primary TPAD failure.

STATUS

Flight qualified. Flown on specific STS flights.

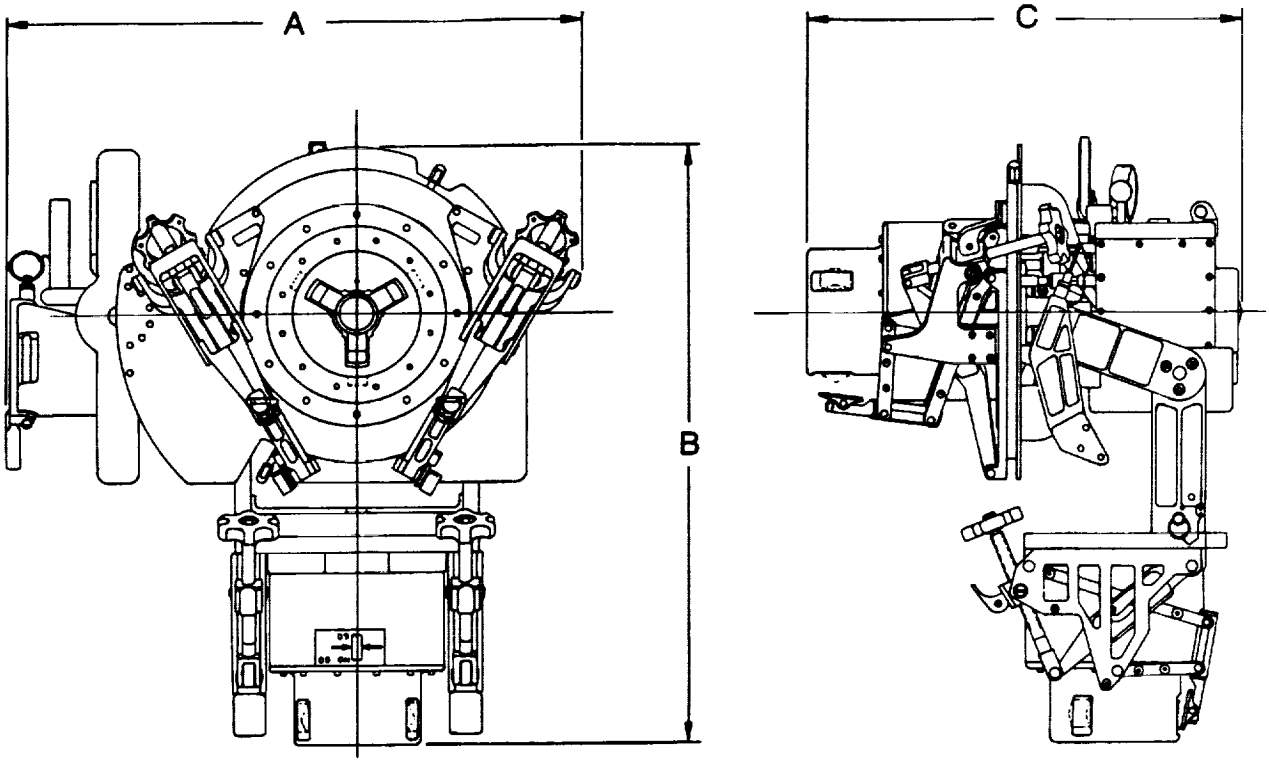
CONTACTS

Source: M. Withey, ILC Space Systems, (713)488-9080
Operational: R. C. Trevino, NASA/JSC/DF, (713)483-2597

TRUNNION PIN ATTACHMENT DEVICE

Technical Information	
Part Number	10169-10069
Weight	106.5 lb
Quantity Flown	One for STS-41B and 41C
Stowage	Flight support system locker and special equipment stowage assembly

Dimensional Data	
A	27.22 in.
B	28.48 in.
C	20.78 in.

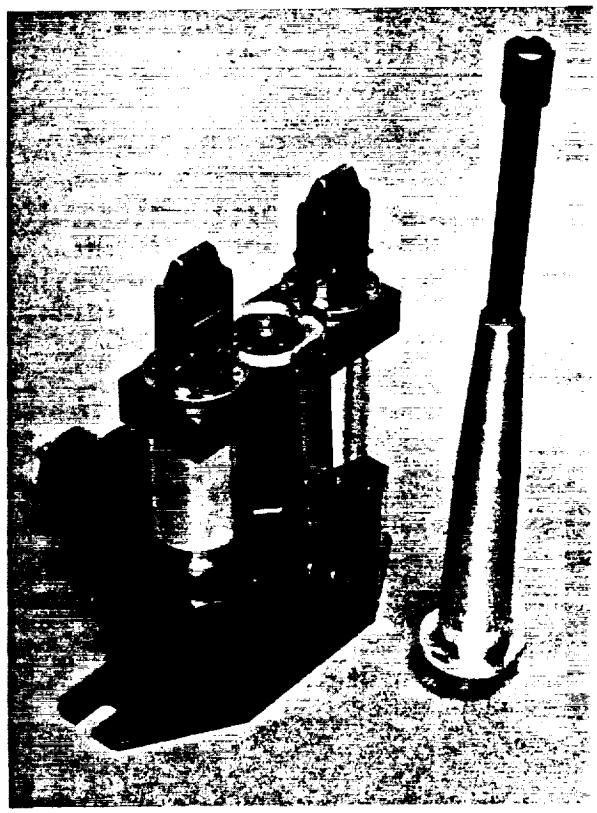


Universal Service Tool

OVERVIEW

The UST is a Spar concept for a flight power tool that allows changeout of the tool attachments on orbit.

Designed to anchor itself to a payload, spacecraft module, or orbiter, the UST can be used to remove or tighten bolts, and operate latches and fasteners while reacting the resulting torque to the anchor points. The UST comprises a control module, a drive module, and interchangeable tool elements.



OPERATIONAL COMMENTS AND INTERFACE PROVISIONS

The UST can be operated manually by an astronaut (as a NASA GSFC version was used on the Solar Maximum Mission - SMM), or operated remotely when attached to a manipulator arm. With anchor latches engaged, the tool can be used to maneuver, position and replace modules.

The range of replaceable tool elements available with the UST provides an astronaut with the operational flexibility to perform a variety of module changeouts and repair tasks in space. EVA handgrips can be attached to the UST for manual operation. For remote operations the UST is attached to the end effector of a remote manipulator arm.

Attached to the end effector of a remote manipulator arm, the UST has demonstrated, on test, its capability to carry out orbital replacement unit changeouts on OMV. By reacting the resulting torque to the anchor points, the UST can be used to remove or tighten bolts, operate latches and fasteners, and cut, drill and impact-chisel materials. Other design advantages include:

- All functions have full manual override
- Tool elements are easily exchanged
- Torque values and speeds are monitored
- Full latching/delatching verification
- Latching torque can be limited to specific value, allowing greater available torque capacity for delatching
- High starting torque latch-drive motor
- Independent latch-drive motors provide redundancy

UNIVERSAL SERVICE TOOL

STATUS

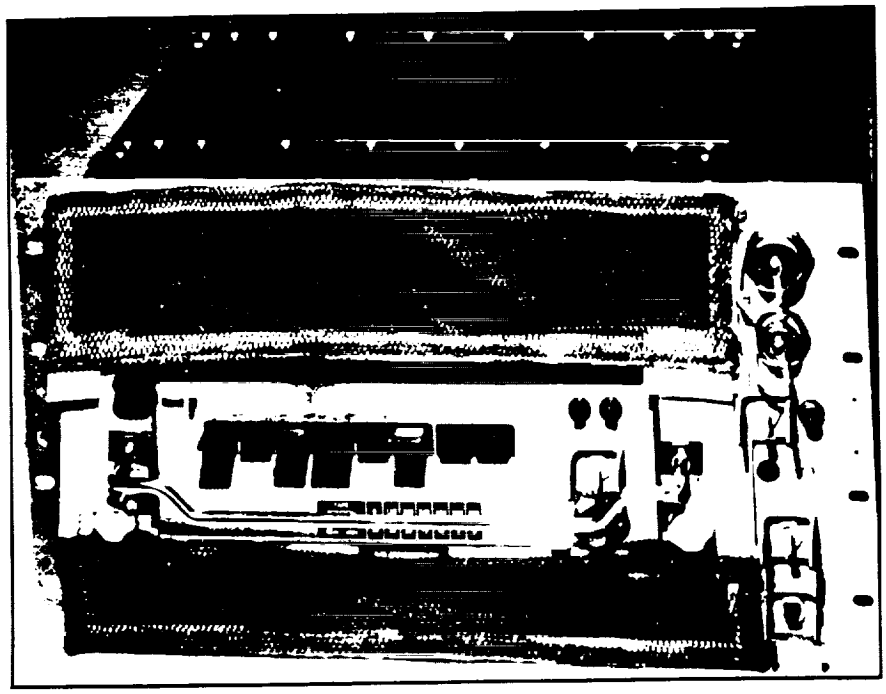
Engineer model undergoing extensive performance testing. Not flight qualified at this time.

CONTACTS

Source: Spar Aerospace Limited, 1700 Ormont Drive, Weston, Ontario, Canada M9L 2W7
Operational: B. Fuller, Spar/Business Development, (416)745-9680, Telex: 065-27360

Technical Information	
Screw Drive Motor	115Vac induction, 400 Hz, 2 phase Stall Torque - 2000 lb. in. Running Torque - 60 lb. in. Running Speed - 35RPM
Latch Drive Motor	28Vdc - Perm. Mag. Stall Torque - 490 oz. in. Running Torque - 99 oz. in. Running Speed - 90RPM
Unit Length	26 in.

Video Tape Recorder



OVERVIEW

The Video Tape Recorder (VTR) is used to record video signals from the Closed Circuit Television (CCTV) system because continuous downlink transmission is not presently possible.

OPERATIONAL COMMENTS AND INTERFACE PROVISIONS

The VTR is an off-the-shelf recorder that has been modified for spaceflight. The VTR is rack mounted in the payload equipment modules of the Aft Flight Deck and is safe for crew operation in a closed-cabin environment. The VTR is mounted so that it can be exchanged during flight with a spare. The VTR has the capability to record and play back black-and-white and National Television Standards Committee (NTSC) color video signals. The VTR is a cassette type recorder for easy operation.

STATUS

The VTR is flight qualified. Flown on specific STS missions.

CONTACTS

Source: Lockheed-EMSCO, 2400 NASA RD. 1, Houston, TX 77058
Operational: Curtis Hyman, EE2, (713)483-0188

REFERENCES

Space Shuttle Program Operational Video Cassette Recorder, Ground Support Equipment Program Requirement Document. JSC-18690.

VIDEO TAPE RECORDER

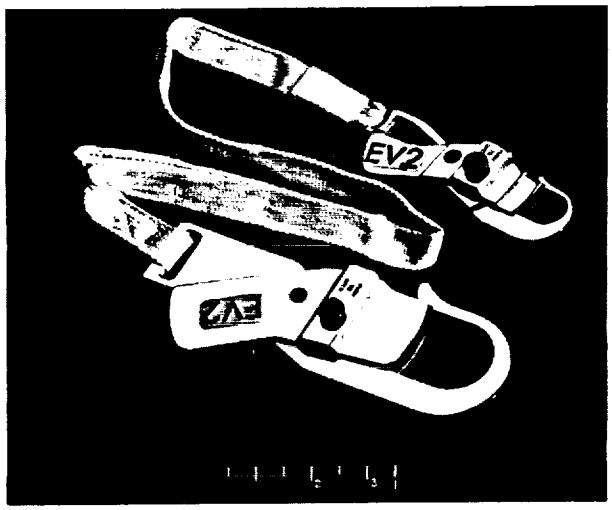
Technical Information	
General	
Video Recording System	Rotary, 2 heads, helical scan system, frequency modulation (FM) recording
Video Signal System	Electrical Industries Association (EIA) black-and- white or NTSC color
Power Source	28 ± 4 Vdc unregulated
Power Consumption	50 W (maximum)
Weight	50 lb
Operating Temperature	-10° to +55° C
Operating Humidity	0 to 80 percent relative humidity

Video Signals	
Input	1 VP-p, negative sync, 75 ohms balanced
Output	1 VP-p, negative sync, 75 ohms balanced, tip of sync direct current restored to 0 Vdc
Signal-to-Noise Ratio	>43 dB
Bandwidth	-8 dB, relative to 1 MHz, at 4.2 MHz

Audio Signals	
Input	-9 to +13 dBm, 0 dBm nominal 600 ohms balanced
Output	+27 dBm maximum, 0 dBm nominal, 600 ohms balanced
Frequency Response	200 H_z to 10 kH_z, ±3 dB
Signal-to-Noise Ratio	>40 dB

Tape Transport	
Tape Speed	95.3 mm/sec (3-3/4 in./sec)
Time base Stability	10 µs relative to a field period
Recording Time	30 min continuous time with KCS-30S video cassette "S" tape

Waist Tether



S83-35198

OVERVIEW

The waist tether consists of a strip of Nomex webbing material with an aluminum EVA hook on each end (one hook is larger than the other). The fully extended tether is approximately 44 inches long including the hooks. The tether incorporates a load-limiting feature which allows no more than 75 pounds to be imparted to the extravehicular mobility unit (EMU) until full extension of the tether occurs. If this load is exceeded, the tether will break, and the shock will be absorbed by the additional segment of webbing which allows the tether to accept loads of up to 585 pounds.

OPERATIONAL COMMENTS AND INTERFACE PROVISIONS

Waist tethers are used to attach the crewmember to a worksite or to tether an otherwise unrestrained tool to the crewmember. The large hook is attached to handrails, and the small hook is attached to an EMU waist tether ring. Opening of an EVA hook requires that push-to-open buttons on each side be depressed simultaneously while the hook is squeezed. The hook will spring-close as soon as it is released. The small hook opens 0.75 inch, and the large hook opens 1 inch. Two waist tethers are normally attached to each EMU.

STATUS

Flight qualified. Flown on all STS flights.

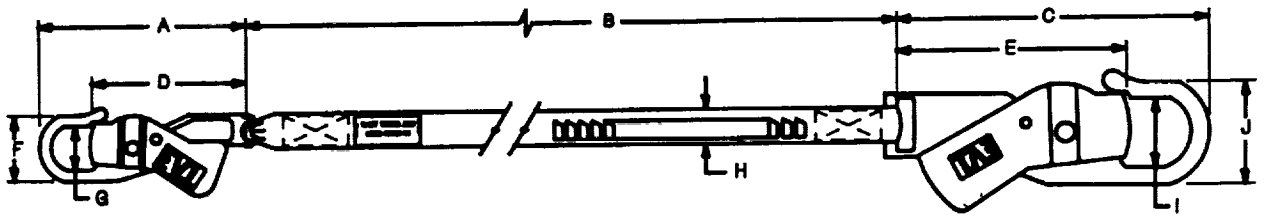
CONTACTS

Source: M. Withey, ILC Space Systems, (713)488-9080
Operational: C. H. Armstrong, NASA/JSC/DG, (713)483-6226

WAIST TETHER

Technical Information	
Part Number	10151-20040-04
Weight	0.93 lb
Material	Nomex, webbing strap, aluminum hooks
Webbing Breaking Strength	1400 lb
Load Limit Before Extension	75 lb
Operational Load Limit	585 lb
Quantity Flown	Two for each EMU

Dimensional Data	
A	5.00 in.
B	normal - 24.0 in. break-away 50.0 in.
C	7.25 in.
D	4.00 in.
E	5.25 in.
F	1.3 in.
G	0.75 in.
H	0.7 in.
I	1.5 in.
J	2.3 in.

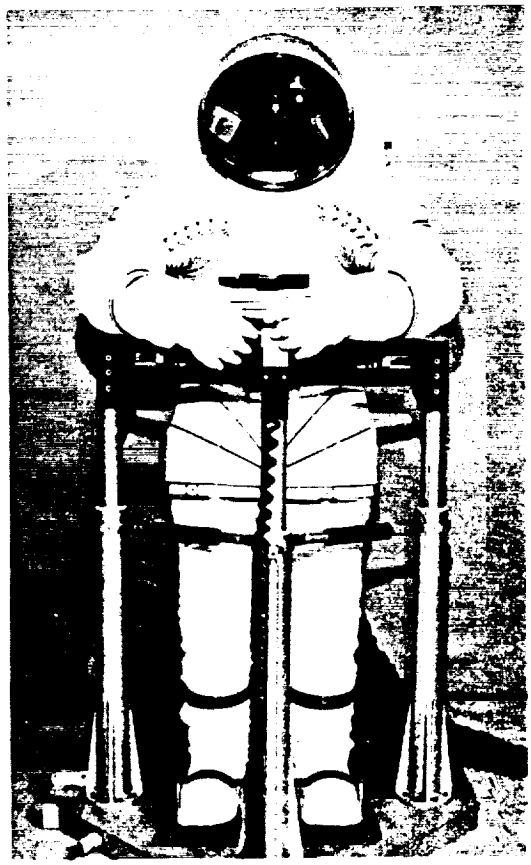


WAIST TETHER

Zero Prebreathe EMU

OVERVIEW

The Zero Prebreathe EMU is an advanced-development, higher-operating-pressure space suit system which enables crew members to accomplish extravehicular operations on a routine basis without the need for prebreathing.



S88-30185

OPERATIONAL COMMENTS AND INTERFACE PROVISIONS

Current Shuttle Extravehicular Mobility Unit (EMU) operation requires a minimum of 3.5 hours of prebreathing pure oxygen before extravehicular activity (EVA). This prebreathing denitrogenates the blood and prevents the crew members from getting the 'bends' during EVA.

The Zero Prebreathe EMU operates at a suit pressure of 8 lbs per square inch (psi). compared to the 4.3 psi operational pressure of the Shuttle EMU. Modular in construction, it consists of a separate hard upper torso, a hard/flexible element lower torso assembly, and interchangeable shoulder, elbow, wrist, and glove assemblies. The construction features of the upper and lower torso assemblies vary, making use of rolling convolute, multibearing, and fabric joint mobility systems. Mechanical attachment of joints to fabric is used to increase suit integrity. Modularity allows quick and easy breakdown of parts for cleaning, resizing, inspection, and stowing. The suit provides three-axis movement for the shoulder, wrist,and hip joints; two-axis movement for ankle joints; and single-axis movement for the waist and for elbow and knee joints.

STATUS

Presently in the technology development stage. Presently planned for flight by mid-1990's and will be used for on-orbit space station activities.

CONTACTS

Source: Hamilton Standard
Operational: Joseph J. Kosmo, NASA/JSC/EC, (713)483-9235

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APPENDIX A
ACRONYMS AND ABBREVIATIONS

ABS	Antenna Bridge Structure
ACD	Apogee Kick Motor Capture Device
ACS	Attitude Control System
AFD	AFT Flight Deck
AGF	Auxilliary Grapple Fixture
AKA	Active Keel Assembly
AKM	Apogee Kick Motor
APC	Adaptive Payload Carrier
ASE	Airborne Support Equipment
AUC	Automatic Umbilical Connector
AWG	American Wire Gauge
BAPS	Berthing and Positioning System
BPC	Bridge Payload Carrier
CCD	Charged Coupling Device
CCTV	Closed Circuit Television
CMD	Command
COBE	Cosmic Background Explorer
CRL	Central Research Laboratory
CRT	Cathode-Ray Tube
CSA	Containerless Support Assembly
DFI	Developmental Flight Instrumentation Carrier
DOD	Department of Defense
DOE	Department of Energy
DPC	Delta Payload Carrier
DSN	Deep Space Network
EAPC	Extended Adaptive Payload Carrier
ECLSS	Environment Control and Life Support System
EFGF	Electrical Flight Grapple Fixture
EGF	Electrical Grapple Fixture
EIA	Electrical Industries Association
EMI	Electromagnetic Interference
EMP	Electromagnetic Pulse
EMU	Extravehicular Mobility Unit
EP	Explorer Platform
EPP	EVA Power Package
ATR	Eastern Test Range
EVA	Extravehicular Activity
FM	Frequency Modulation
FSS	Flight Support System
FSS/SAT	Flight Support System/Servicing Aid Tool
FTS	Force Torque Sensor
FWD	Forward

GAS	Getaway Special
GFE	Government Furnished Equipment
GN&C	Guidance, Navigation and Control
GRO	Gamma Ray Observatory
GSE	Ground Support Equipment
GSFC	Goddard Spaceflight Center
HMD	Helmet Mounted Display
HST	Hubble Space Telescope
ICAPC	Increased Capability Adaptive Payload Carrier
ICD	Interface Control Document
ILC	International Latex Corporation
IUS	Inertial Upper Stage
IVA	Intravehicular Activity
JPL	Jet Propulsion Laboratory
JSC	Johnson Space Center
LDS	Laser Docking System
LEMSCO	Lockheed Engineering and Management Services Company
LMSC	Lockheed Missiles and Space Company
LROEFU	Linear Remotely Operated Electrical/Fluid Umbiliical
LROEU	Linear Remotely Operated Electrical/Umbiliical
LWGF	Lightweight Grapple Fixture
MDAC	McDonnell Douglas Astronautics Company
MDF	Manipulator Development Facility
MEE	Magnetic End Effector
MFR	Manipulator Foot Restraint
MIL	GSFC Spaceflight Tracking and Data Network Station (KSC) Merritt Island, Fla. (STDN Site)
MIL	Military
ML	Middeck Left
MMH	Monomethylhydrazine
MMS	Multi-Mission Modular Spacecraft
MMU	Manned Maneuvering Unit
MPM	Manipulator Positioning Mechanism
MPS	Modular Power Subsystem
MRL	Manipulator Retention Latch
MSFC	George C. Marshall Space Flight Center
MST	Module Servicing Tool
NASA	National Aeronautics and Space Administration
NSTS	National Space Transportation System
NTO	Nitrogen Tetroxide
NTSC	National Television Standards Committee
OFK	Official Flight Kit
OFT	Orbital Flight Test
OMV	Orbital Maneuvering Vehicle
OMV	Oxygen Manual Valve
ORU	Orbiter Replacement Unit

OSCRS	Orbital Spacecraft Consumables Resupply System
OSF	Office of Space Flight
PACS	Payload active Cooling/Heating System
PAM	Payload Assist Module
PAM-D	PAM, Delta Class Spacecraft
PAM-D	Payload Assist Module D
PBS	Payload Berthing System
PCD	Procurement Control Document
PEBW	Partable Electron Beam Welder
PED	Platform Equipment Deck
PFR	Portable Foot Restraint
PIM	Payload Interface Mechanism
POCC	Payload Operations Control Center
PRLA	Payload Retention Latch Actuators
PRT	Power Ratchet Tool
psi	Pounds per Square Inch
QD	Quick Disconnect
RCA	Radio Corporation of America
RCS	Reaction Control System (Subsystem)
REU	Remote Electrical Umbilical
RI	Rockwell International
RMS	Remote Manipulator System
RMS/HPA	RMS-Based Handling and Positioning Aid
ROEU	Remotely Operated Electrical Umbilical
RSO	Rotary Shut-Off
SACS	Strap-On Attitude Control System
SAMSIN *	Servo-Actuated Manipulator System with Intelligence Networks
SCCS	Standard Cubic Centemeters per Second
SCE	Satellite Checkout Equipment
SEE	Standard End Effector
SIP	Scientific Instrument Package
SIP	Standard Interface Panel
SMCH	Standard Mix Cable Harness
SMCH	Standard Mixed Cargo Harness
SMM	Solar Maximum Mission
SPDS	Stabilized Payload Deployment System
SRAD	Shuttle Radiator Assembly Demonstration
SSP	Space Shuttle Program
STS	Space Transportation System
SURS	Standard Umbilical Retraction-Retention System
SURVS	Standard Umbilical Retraction Vent System
TBS	To Be Specified
TDRSS	Tracking and Data Relay Satellite System
TLM	Telemetry
TPAD	Trunnion Pin Attachment Device
UST	Universal Service Tool

VTR	Video Tape Recorder
WTR	Western Test Range
* -	TRADEMARK

KWS:

1. SPACECRAFT EQUIPMENT
2. ONBOARD EQUIPMENT
3. CATALOGS
4. ORBITAL SERVICING
5. ARTIFICIAL SATELLITES
6. SPACE MAINTENANCE
7. MAINTENANCE
8. REMOTE MANIPULATOR SYSTEM
9. SPACE SHUTTLE ORBITERS
10. EQUIPMENT SPECIFICATIONS